SAMPLING AS A TECHNIQUE FOR IMPROVING THE EFFICIENCY OF MARKETING EGGS ON A GRADED BASIS

DISSERTATION

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By

PAUL CHESTER CLAYTON, B. S., M. S.

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Approved by:

Raymond E. Gray
Adviser

Department of Poultry Science

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INTRODUCTION

Buying and selling are the essence of marketing. Without both buying and selling there is no marketing. In analysing marketing operations in terms of the creation of time, place, form, and possession utilities, it can be said that buying and selling is creating possession utility. That is - getting the possession of goods into the hands of those who want them more and out of the hands of those who want them less - thus satisfying a higher level of wants.[1]

One of the "Facilitating functions"[2] of marketing is standardization. Maynard and Beckman[3] define standardization as involving "the determination of basic measures or limits to which articles being standardized must conform and includes the process of conforming to such standards."

Standards are descriptions of one or more characteristics of goods which divide those on the market into two or more groups called grades.[4] Grading which involves rating or ranking goods is part of

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1 Nervik, Ottar, and J.D. Black, Research In Selling and Buying With Special Reference to Goods Sold and Bought by Farm People, Cambridge, Massachusetts, Harvard, June 1946, pp. 1-6.

2 Maynard, Harold H., and Theodore N. Beckman, Principles of Marketing, 4th Edition, New York, Ronald Press, 1946, p. 30.

3 Ibid. p. 452.

4 Coles, Jessie V., "Research in the Improvement of Standards and Grades," A Report of the Marketing Research Workshop, U.S.D.A. 1953, p. 69.

standardization. It tests the conformity of commodities to standards that have been set up previously.

Standardization makes it possible for producers of agricultural products to buy and sell their products on the basis of quality as well as quantity.

Standardization can also reduce marketing costs by making it possible to (1) buy and sell by description rather than physical inspection, (2) carry on future trading, (3) make more efficient use of storage and transportation, and (4) facilitate financing.

Lower marketing costs could increase returns to producers and/or lower the price to the consumer. The amount would depend, in part, on the competitive situation. It is often possible for the producer to get a higher return for his product by selling on a graded basis, providing (1) he produces the grades which command the higher prices, (2) the standards or grades have been correctly established, and (3) the grades are easily determined.

The effectiveness or value of standardization in the buying and selling of agricultural products as in maximizing financial returns to producers or other benefits would depend in large part on:

1. The extent to which the standards cover the products being produced and marketed, and the extent to which the standards are used. In order to be effective, standards must be set up for the whole crop from the top to bottom and not just an ideal goal. They must also be useful and understood not only by producers and marketing agencies but by all buyers and sellers as well. The wider the use - the more valuable a standard becomes.

2. The accuracy of the standards - is determined by the extent to which they reflect the characteristics that all buyers recognize and which influence the amount they are willing to pay for the product. Unless standards reflect these charactieristics, they are of little value in paying producers for the quality produced.

3. The accuracy of the grading - is the accuracy with which the above characteristics are recognized in the grading process. The standard must be based on factors that are dependable and can be uniformly applied. A standard is of little value if there is no accurate method of placing the products in the various grades.

4. The cost of grading - is an important factor in the use of standards. Standards must be based on factors that are practical to apply. Although nutritional values should logically be an important factor in determining the value of agricultural products, they are not included in most standards because of the lack of any quick and practical method of testing for nutritional values.[1]

REASONS FOR THE STUDY

The use of standards and grades in determining payments to producers for eggs (paying on the basis of not only quantity but size and

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1 McCallister, Kenneth J., "Principles and Practices in Development of Standards for Grades of Agricultural Products." A Report of the Marketing Research Workshop, U.S.D.A. 1953, pp. 61-63.

quality) is a sound practice.[1] One of the major factors limiting the more extensive use of grades in determining payments for eggs is the cost of the grading.

If eggs are bought on a "graded basis", a record must be made of the number of eggs in each of the various grades for each shipment from every producer. When a producer's shipment contains 10 to 15 different grades (sige and quality) with a different paying price for each grade, it becomes an expensive operation to keep these records and compute the payments. Since the eggs from each producer must be kept separate until they are graded, this prevents the most efficient handling of the eggs and also the use of the most efficient grading equipment. The cost of grading thus becomes a major problem in the Mid-West where most of the egg production comes from a large number of small flocks.

This study is concerned primarily with investigating possible methods of reducing the cost of buying eggs on a "graded Basis". In the study of more economical methods of paying producers on the basis of quality, these methods should be compared with the present methods with regard to accuracy as well as cost. It is therefore important to first determine the accuracy or amount of variation which occurs in the present method of grading eggs for size and quality.

The "accuracy of grading", another factor in influencing the effectiveness of the use of grades in the buying and selling of eggs is also considered in this study along with the cost of grading. If a less

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1 Cray, Raymond E., "Why We Buy Eggs on Grade", <u>U.S. Egg & Poultry Magazine</u>, Vol. 54, No. 5, 1948, pp. 7-9.

costly method of paying producers for eggs on a "graded basis" can be developed which still reflects to the producer the true value of the quality produced, it would expand the use of grades in buying and selling eggs and at the same time it would encourage quality improvement.

OBJECTIVES

The objectives of this study were to:

I - Determine the accuracy of the present methods of buying and grading eggs according to the U.S. Department of Agriculture Shell Egg Standards. Human judgment is involved in our present methods of egg grading so some variation is to be expected in the grading of eggs by different graders or candlers.[1] Some variation must also be expected in the work of the individual candler. One objective of this investigation is to measure the extent of these variations.

II - Investigate the possibilities of using sampling techniques in determining the quality and size of eggs. One possible method of reducing the costs of buying eggs on a "graded basis" would be the grading of samples of eggs as a method of determining the size and quality of an entire shipment or of several succeeding shipments of eggs from the same producer.

After determining the accuracy of egg grading methods (Objective I) it was necessary to attempt to determine the size and the frequency of a sample that would be required to give as accurate a measurement of size and quality in determ-

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1 In this study the words "grader" and "candler" are used interchangeably.

ining producer payments as the grading of the entire shipment.

III - Combine the findings in objectives I and II into a sound, economical and practical operating plan for making payments to producers that will reflect a fair price in relation to the size and quality of eggs sold.

CANDLING EGGS

As previously mentioned there are other factors besides costs and accuracy of grading methods which determine the effectiveness of the use of "grades" in buying and selling agricultural products, such as, the degree to which the standard reflects those commodity characteristics that all buyers recognize and influence the amount which they are willing to pay.

One of the problems in establishing standards is the locating of boundaries between grades. The range of any quality or characteristic placed in an array is a gradual shading from one unit to the next, for example, the size of an air cell, the albumen height, or the size of an egg. The grouping into a grade is an arbitrary decision. The location of boundaries between grades will depend upon the degree to which various users will pay premiums for certain qualities rather than substitute adjacent qualities within the ranges available.[1]

Candling is the only method of grading shell eggs for interior quality that is being used by industry at the present time. Candling

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1 Erdman, H.E. "Problems in Establishing Grades for Farm Products", Journal of Farm Economics, XXXII, February, 1950, pp. 15-29.

consists of visual inspection of eggs for certain interior and exterior qualities and characteristics. This is done with the aid of a light, which is nothing more than a 40 or 60 watt bulb enclosed in a box with a one inch round opening through which the light shines and before which the egg is rotated. Van Wagenen[1] describes candling as "a study of lights and shadows". The following characteristics and/or conditions of the shell egg may be observed by candling:

Shell: soundness, texture, cleanliness and shape

Air cell: size and movement

Albumen: clarity, firmness, and defects

Yolk: position, outline, and defects

The U.S. Department of Agriculture Standards[2] for individual shell eggs include four quality grades - AA, A, B, and C. The specifications for each grade are based on the above characteristics.

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1 Van Wagenen, Alfred, Grading Eggs - A Manual For Egg Grading Schools, Trenton, New Jersey, Northeastern Poultry Producers Council, 1949.

2 U.S. Standards, Grades and Weight Classes for Shell Eggs, U.S. Department of Agriculture, Washington D.C., 1952.

VARIATIONS IN EGG GRADING

REVIEW OF LITERATURE

A number of studies have been made of the accuracy of candling as a means of detecting shell quality, size of air cell, condition of albumen and yolk, and the relationship of the candled appearance to the quality as determined by scoring the broken-out eggs. Based on the research to determine the quality of shells of eggs by candling, Baker and Forsythe[1] concluded that candling can only detect extreme abnormalities in the shells such as very thin shells, cracks, etc. Candlers frequently confuse mottling of the shell which is due to loss of shell moisture with defects in shell texture.

Size and movement of the air cell is another characteristic observed in the candling of eggs. Stewart, Gans, and Sharp[2] found considerable lack of agreement as to the size of air cells. These workers showed that often the interior quality of the egg may be quite out of line with the size of the air cell. The size of the air cell unfortunately, very often exerts a large psychological influence on the candler's opinion of the other characteristics of the egg. Candlers tend to lower their scores of the white whenever the air cell is large. Lowering of the albumin score because of the size of the air cell often bears no relationship to the actual condition of the white, except in the case of very poor quality eggs.

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1 Baker, Ralph L., and Richard H. Forsythe, "U.S. Standards of Quality of Individual Shell Eggs and the Relationship Between Candled Appearance and More Objective Quality Measures." Poultry Science, Vol. 30, No. 2, March, 1951, pp. 269-277.

2 Stewart, G.F., A.R. Gans, and P.F. Sharp, "A Summary of the Average Candlers' Grades With Opened Egg Scores on 59 Dozen Eggs." U.S. Egg & Poultry Magazine, 39 (2), pp. 37-39.

In studies of the condition of the albumen as determined by candling, Hoover[1] found no correlation between the area measurement of thick white and the candling grade of the grader. Pennington[2] also found little difference in percentage of thick white between the different grades of eggs segregated on the basis of the U.S. Shell Egg Standards. The condition of the albumen is determined in candling by the position, outline, and mobility of the yolk. Baker and Forsythe[3] concluded from the literature available, that centering of the yolk is not a satisfactory criterion of quality; yolk outline within limits has considerable merit but is greatly influenced by the color of the yolk.

There is not only the question of whether or not the characteristics or conditions listed in the Standards are related to the quality of the egg, but there also is the question of the ability of candlers to recognize these characteristics or conditions. The classifying of eggs into the four quality grades on the basis of these factors is a subjective method based on human judgment. Obviously, the rapid rotating of an egg before a candling lamp to determine such things as size of air cell, yolk outline, mobility of yolk, etc. is subject to human error.

Stewart, Gans and Sharp[4] conducted an experiment on the variation among candlers. In this experiment 61 dozen eggs were candled by four

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1 Hoover, S.R. "Determining of Egg Quality by a Sampling Method." Experiment Station Record, 80 p. 299.

2 Pennington, M.E. "Yolk Index and Thick White in Eggs Graded by Candling for Interior Quality", U.S. Egg & Poultry Magazine, Vol. 40 (5), pp. 43-46.

3 Baker, Ralph L. and Richard H. Forsythe, OP. Cit. pp. 275.

4 Stewart, Gans, and Sharp, Op. Cit., 38 (5) pp. 31-34.

graders. The eggs were candled into four grades, then each grade was sub-divided into a "high" and "low" class - thus placing the eggs into 8 classes. An average score was computed for each dozen. They concluded that candlers agree fairly well on fine quality eggs and on the poor quality eggs, but disagree in some cases quite radically on the medium quality eggs. There was surprising good agreement between graders when the eggs were grouped into four grades, although there was considerable variation among the individual eggs. It is interesting to note that the egg graders agreed much better on the actual grade of an egg than they did on why they put it in a particular grade. In determining the variation in grading among candlers this experiment may not reflect conditions as they exist in industry because: (1) the small number of graders tested and size of the egg sample, (2) the graders used were probably better than average, because they were selected as good graders, (3) the graders knew they were being tested, (4) the test eggs were graded four times.

Burrows and Brant[1] conducted an experiment to determine whether or not repeated candling of an egg altered its quality as measured by candling. In this test 3 eggs from each of the four quality grades (AA, A, B, and C) which had been candled by the test operator were selected. These 12 eggs were then interspersed at random among 18 other eggs. These eggs were then candled a predetermined number of times by other operators. The test operator then candled all eggs a

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1 Burrows, Glenn L., and A.W. Brant, "Measuring Changes In Quality When Quality Standards are Subject to Errors in Interpretation", U.S. Department of Agriculture, Washington D.C., 1952.

second time, unaware of the treatment given any tray and unaware of which were test eggs and which were not. Records were taken of his scoring of individual test eggs on his first and second candling after 0, 2, 4, 6, 8, or 10 nonrecorded candlings had been applied to the eggs. Pearsonian correlation coefficients (r) between the initial candling and the operators second candling were computed. The "Z" transformation was applied and regression line computed. Burrows and Brant concluded that - "By examining the consistency or lack thereof among the quality assignments for lots of eggs subjected to progressively greater numbers of candlings, the method developed here makes it possible to detect changes in quality, despite the fact that errors may be made in quality assignment at any candling. Theoretical considerations of the adequacy of the techniques are borne out in the applications. The sensitivity of the technique is sufficient to show a significantly greater decline in candled quality with increased number of candlings among white shell eggs than among brown shelled eggs. It was also shown that six or more candlings of eggs caused a significant change in the candled quality."

Since egg candling is almost entirely a matter of human judgment, Lucal[1], after determining there was a significant variation in the grading of eggs among the graders, went on to investigate the factors that affected this judgment and to what extent. In order to find out whether or not there was a significant difference among candlers and

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1 Lucal, Kenneth G., A Statistical Analysis of Variation Among Egg Candlers, Unpublished Master's Thesis, The Ohio State University, Columbus, Ohio, 1950.

whether or not the time of day was important, five test cases of 180 eggs were made up. They consisted of several grades and an attempt was made to get them as nearly alike as possible. Each of these cases were candled by each of five graders during certain periods of the day. In this test it was impossible to distinguish the amount of variation due to time of day and that due to deterioration in quality. The assumption was made that if there is a change in quality it will be down rather than up and any improvement in quality must be due to other causes. The latin square type of experiment with four tests (Bartlett's, Cochran's, "T", and "F" tests) was used. From the experiment Lucal concluded that at a 5% significance level many candlers are grading unlike others in their respective grading plants. In another experiment in which candlers graded a sample of eggs and then regraded these same eggs after a training period, Lucal found that at a 5% significance level there were significantly fewer variations from the standard after the training period. He concluded that inadequate training could well be an important factor in the variation in the grading of eggs by different candlers. In these experiments the candlers know they were being tested and undoubtedly were grading with greater than normal care.

EXPERIMENTAL DESIGN

One of the objectives of this study was to determine the uniformity and accuracy of the present method of candling the eggs sold by producers, and its effect on the average price received by the producer. This phase of the study was not concerned with the specific factors causing this variation but was designed to compare the present method of determining producer payments with more economical methods - such as sampling.

In order to evaluate the actual extent of the variation in the accuracy of grading between candlers, the candling operations in two plants were studied. In these egg assembling plants each egg was individually hand candled for interior quality with a standard candling lamp and graded for size by a machine according to the U.S. Department of Agriculture Standards. Neither plant separated out the "AA" quality eggs from the "A" grade. The grading in both plants was under the supervision of a Federal-State egg grading inspector.

In most of the previous research on candling accuracy, the candlers knew they were being tested and hence were probably more careful in their work than under ordinary conditions. This experiment was purposely designed to keep the candlers from knowing that their grading was being checked in order to eliminate any effect that might otherwise result.

At irregular monthly intervals the investigators entered the plants after the candlers had finished work for the day. A random selection was made of cases of different grades of eggs that had been graded that day by one or possibly two of the candlers to be tested. Using these graded eggs as a source of supply, two identical samples of one case each were prepared for every candler to be tested.

The identical samples or test cases of eggs were prepared by lining up the empty sample cases in a row and then taking from the supply case of grade A-large eggs, samples of 18 eggs and placing one sample in the bottom filler on one side of each of the sample or test cases. In a similar manner 12 grade B-large eggs were selected from the Grade B-large supply and put in the same filler and next 6 Grade C eggs were selected from the supply case of this grade to finish filling the filler in the sample case. Each of the other 10 fillers in every sample case was filled in the same manner, so that the resulting sample or test cases contained eggs of as near identical size and quality as humanly possible to select in any practical manner. Each completed sample or test case contained 180 Grade A Large, 120 Grade B Large, and 60 Grade C eggs according to the original grading.

Each sample or test case was then identified with a case card filled out with the name of a fictional producer in a manner similar to the case card on a regular shipment from a bona fide producer.

Two sample or test cases were then placed in the supply of ungraded cases of eggs to be graded the next day by each of the candlers to be tested. Since each sample or test case had the name of a different producer on the case card, each candler unconsciously graded two identical samples. The results of the grading of the sample or test cases went to the office along with the grading results on the eggs from actual producers, and the data on the grading of the sample was secured by the investigators at that point.

Plant No. 1: In this central egg assembling and grading plant the candler graded the eggs for interior quality into grades A, B, C, checks[1] and inedibles. The A and B grade eggs were placed on a siz-

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[1] checks: cracked eggs

ing machine by the candler and the machine separated both the A and B grade eggs into Jumbo, Large, Medium, and Small sizes. The grade C eggs, checks, and other under grades were not size graded.

After each shipment of eggs was graded, the exact number of eggs placed in each of the various grades and size classification was recorded on case cards provided by the organization and used by the producer to identify each case of eggs in his shipment. Six girls (3 candling white eggs and 3 candling brown eggs) were involved at this plant in each of the 12 grading tests between April 3, 1952 and August 11, 1953.

The candlers were selected by the management as being representative of the more experienced candlers in the plant. Since this project was to run for more than a year, the probability of the candler continuing to work at the plant during the period was also taken into consideration, since there is a rather high turn-over in women performing this task. A total of 14 candlers at this plant actually participated in the tests during the 17 months period.

The following tables show the results of the tests. The eggs used in each identical test sample were originally graded by one of the candlers being tested. In each of the tests, it is indicated which grader originally candled the eggs that were used in the identical samples. In some of the tests all the eggs used in the samples were candled originally by one grader, while in other tests, the identical sample cases of eggs were made up of eggs originally graded by two or three of the candlers. Each identical sample case of eggs contained 180 Grade A Large, 120 Grade B Large, and 60 Grade C

Assorted eggs. The two case sample candled by each grader consisted of 360 Grade A Large, 240 Grade B Large, and 120 Grade C Assorted eggs according to the initial candling.

TABLE I

Distribution by Grades of Identical Samples of Eggs Graded by Different Graders, Plant No. 1

Test No. 1 - April 3, 1952

Grade	White Eggs Candlers			Brown Eggs Candlers		
	S	L	N	C	X	G
Jumbo A	0	30	33	16	25	13
Large A	0	325	416	367	475	335
Medium A	0	16	17	26	7	26
Small A	0	0	3	0	4	3
Large B	649	283	196	202	110	261
Medium B	17	2	5	4	12	27
Grade C	33	41	21	85	50	34
Checks	11	15	14	14	19	8
Other	3*	0	0	1*	12**	3*
Bloods	7	8	15	5	6	10
Total	720	720	720	720		720

Initial Candler: white eggs - S, brown eggs - X
* leakers, ** dirty

Test No. 2 - June 26, 1952

Grade	White Eggs Candlers			Brown Eggs Candlers		
	S	L	N	E	X	G
Jumbo A	2	42	6	12	15	36
Large A	104	326	250	495	532	501
Medium A	0	36	6	32	28	31
Small A	0	0	0	10	22	13
Large B	484	198	343	48	22	30
Medium B	8	10	23	6	6	6
Grade C	77	76	67	106	56	87
Checks	31	22	21	11	20	14
Other	8*	2**	0	0	6***	0
Bloods	6	8	4	0	13	2
Total	720	720	720	720	720	720

Initial Candler: white eggs - L, brown eggs - all 3
* leakers, ** rot and stuck yolk, *** stained

TABLE I (Continued)

Test No. 3 - Aug. 23, 1952

Grade	White Eggs Candlers			Brown Eggs Candlers		
	S	L	N	T	X	G
Jumbo A	11	32	4	8	9	5
Large A	223	321	182	252	480	217
Medium A	83	71	17	7	28	21
Small A	44	47	5	8	27	5
Large B	239	181	335	247	80	318
Medium B	24	7	48	23	9	3
Grade C	42	31	105	104	38	103
Checks	42	21	16	51	39	26
Other	8*	1*	1*	9**	6*	14***
Bloods	4	8	7	11	4	8
Total	720	720	720	720	720	720

Initial Candler: white eggs - N, brown eggs - G
* leakers, ** 4 dirty, 2 rots, and 3 leakers,
*** 2 rots and 12 leakers

Test No. 4 - Oct. 1, 1952

Grade	White Eggs Candlers			Brown Eggs Candlers		
	S	L	N	E	X	G
Jumbo A	25	6	3	8	40	2
Large A	215	148	203	339	362	88
Medium A	100	21	33	61	67	39
Small A	44	22	23	36	22	7
Large B	264	385	333	172	129	439
Medium B	10	30	73	32	12	32
Grade C	25	77	40	51	25	90
Checks	29	21	6	11	46	16
Other	1*	0	0	9**	12***	3
Bloods	7	10	6	1	5	4
Total	720	720	720	720	720	720

Initial Candler: white eggs - all three, brown eggs - all three. * leakers, ** 5 dirty and 4 leakers,
*** 7 leakers and 5 dirty

TABLE I (Continued)

Test No. 5 - Oct. 24, 1952

Grade	White Eggs			Brown Eggs		
	Candlers			Candlers		
	K	L	N	E	X	G
Jumbo A	0	3	1	0	7	2
Large A	149	298	222	60	464	122
Medium A	23	61	42	6	67	87
Small A	8	20	3	0	7	10
Large B	370	199	174	402	82	368
Medium B	118	28	186	43	7	46
Grade C	18	82	75	127	21	46
Checks	9	20	10	20	16	13
Other	0	0	4*	13**	4*	5***
Bloods	25	9	3	49	45	21
Total	720	720	720	720	720	720

Initial Candler: white eggs - all three, brown eggs - all three. * leakers, ** 10 rots and 3 leakers, *** rots

Test No. 6 - Dec. 9, 1952

Grade	White Eggs			Brown Eggs		
	Candlers			Candlers		
	O	L	N	E	X	G
Jumbo A	0	9	4	1	28	4
Large A	0	246	46	170	412	284
Medium A	0	12	13	8	28	87
Small A	0	0	1	0	0	2
Large B	600	312	495	352	187	224
Medium B	25	22	17	13	13	58
Grade C	81	87	125	165	42	37
Checks	13	27	16	6	12	19
Other	0	2*	0	0	0	0
Bleeds	1	3	3	5	0	5
Total	720	720	720	720	720	720

Initial Cnadler: white eggs - L, brown eggs - X
* dirty

TABLE I (Continued)

Test No. 7 - Jan. 20, 1953

Grade	White Eggs Candlers			Brown Eggs Candlers		
	O	L	N	E	X	G
Jumbo A	5	1	4	3	24	0
Large A	243	323	216	291	500	186
Medium A	16	16	14	10	46	13
Small A	0	0	0	0	0	1
Large B	353	227	363	322	82	430
Medium B	40	36	9	9	7	3
Grade C	46	99	100	56	22	66
Checks	12	11	9	19	32	14
Other	3*	0	3*	1*	0	1*
Bloods	2	7	2	9	7	6
Total	720	720	720	720	720	720

Initial Candler: white eggs - N, brown eggs - G
* dirty

Test No. 8 - Mar. 6, 1953

Grade	White Eggs Candlers			Brown Eggs Candlers		
	O	L	N	E	X	G
Jumbo A	7	7	14	1	37	32
Large A	249	348	231	103	437	390
Medium A	5	27	15	8	57	40
Small A	0	0	0	0	1	0
Large B	326	215	315	441	146	173
Medium B	7	14	13	6	1	1
Grade C	89	74	112	104	23	57
Checks	33	19	12	35	15	21
Other	3*	0	0	0	1**	0
Bloods	1	16	8	22	2	6
Total	720	720	720	720	720	720

Initial candler: white eggs - O, brown eggs - E
* dirty, ** leaker

TABLE I (Continued)

Test No. 9 - April 16, 1953

Grade	White Eggs			Brown Eggs		
	Candlers			Candlers		
	O	L	N	E	X	G
Jumbo A	1	12	13	1	13	6
Large A	60	314	152	302	491	302
Medium A	2	16	6	5	15	24
Small A	0	0	1	0	1	4
Large B	521	262	412	265	86	234
Medium B	25	11	4	0	0	27
Grade C	92	79	109	129	94	103
Checks	12	16	9	10	19	13
Other	6*	2*	3**	0	0	0
Bloods	1	8	11	8	1	7
Total	720	720	720	720	720	720

Initial Candler: white eggs - L, brown eggs - X
* leakers, ** 1 rot and 2 leakers

Test No. 10 - June 2, 1953

Grade	White Eggs			Brown Eggs		
	Candlers			Candlers		
	O	I	V	F	X	G
Jumbo A	13	28	3	3	34	16
Large A	153	252	167	27	367	220
Medium A	3	22	0	0	36	8
Small A	0	0	0	0	2	1
Large B	404	362	416	547	174	342
Medium B	11	2	32	13	8	22
Grade C	101	25	83	84	51	70
Checks	25	22	17	36	37	35
Other	10*	7*	2*	6**	9***	5*
Bloods	0	0	0	4	2	1
Total	720	720	720	720	720	720

Initial Candler: white eggs -O, brown eggs - G
* loss, ** 3 loss and 3 dirty, *** 4 loss and 5 dirty

TABLE I (Continued)

Test No. 11 - July 2, 1953

Grade	White Eggs			Brown Eggs		
	Candlers			Candlers		
	O	I	C	F	X	G
Jumbo A	1	8	4	2	10	10
Large A	62	182	277	93	368	432
Medium A	5	45	40	3	21	16
Small A	2	4	6	0	0	3
Large B	503	374	242	481	195	178
Medium B	17	8	16	11	14	11
Grade C	91	56	102	97	66	43
Checks	33	30	23	23	44	15
Other	6*	13**	9***	9****	1*	12*****
Bloods	0	0	1	1	1	0
Total	720	720	720	720	720	720

Initial Candler: white eggs - I, brown eggs - F
* loss, ** 10 loss 3 leakers, *** 8 loss 1 dirty,
**** 4 leakers 5 loss, ----- 10 leaker 2 dirty

Test No. 12 - Aug. 11, 1953

Grade	White Eggs			Brown Eggs		
	Candlers			Candlers		
	V	L	C	E	X	G
Jumbo A	3	3	6	6	24	10
Large A	204	111	266	261	492	374
Medium A	35	6	6	36	54	39
Small A	4	0	8	10	44	24
Large B	333	506	345	279	51	221
Medium B	37	17	4	29	8	14
Grade C	72	56	55	65	27	25
Checks	23	12	24	20	13	5
Other	3*	6**	4***	9****	5***	5***
Bloods	6	3	2	5	2	3
Total	720	720	720	720	720	720

Initial Candler: white eggs - L, brown eggs - X
* 2 dirty 1 rot, ** 2 dirty 4 loss, *** dirty,
**** 5 loss 2 dirty 2 rot

Plant No. 2: The operation of this central egg assembling and grading plant was essentially the same as Plant No. 1. This organization assembles the eggs from farms by regularly established truck routes operated by the organization. The eggs were moved from the trucks to the grading room on roller conveyors. The eggs were candled for interior quality into grades A, B, C, Checks and inedibles. The grade A and B eggs were size graded by a sizing machine. The same type of sizing machines were used in both plants. After grading each shipment, the number of dozen of eggs put in each of the various grades was recorded on the case card similar to the type used at Plant No. 1.

The number of eggs in each grade except checks, bloods, and losses was rounded to the nearest dozen. The candler and packer performed the rounding operation at the time the count was made of the number of eggs in each grade. The rounding procedure helped to reduce the time required to compute payments to producers, since the values for fractions of dozens did not need to be computed. This phase of the operations at the plant was significantly different from the operation of Plant No. 1 where the records were all kept in terms of the exact number of dozen and additional eggs in each grade.

Four candlers, two working with white egg and two working with brown egg were tested in each of the 12 tests between April 10, 1952 and August 12, 1953. The candlers were selected by the management as being representative of the more experienced candlers in the plant. The possibility of the candler remaining on the job during the entire period that the tests were being made was also taken into consideration in the selection of the candlers. Thirteen candlers participated in the tests at Plant No. 2.

The test samples were set up the same way as at Plant No. 1. The eggs used in the tests were initially graded by the candlers participating in the tests. Here again, the candlers did not know they were being tested. In three of the tests (No. 3, 4 and 11) one candler graded the entire test sample (4 cases) of brown eggs because of the absence of the second candler. The results of the 12 tests are given in the following table.

TABLE II

Distribution by Grades of Identical Samples of Eggs Graded by Different Candlers, Plant No. 2

Test No. 1 - April 10, 1952

Grade	White Eggs Candlers		Brown Eggs Candlers	
	R	M	G	S
Jumbo A	48	24	0	0
Large A	372	228	384	276
Large B	180	408	204	336
Medium A	24	12	36	12
Small A	0	0	0	0
Grade C	60	24	48	84
Checks	25	23	40	12
Bloods	11	1	8	0
Total	720	720	720	720

Initial Candler: white eggs R, brown eggs S

Test No. 2 - May 29, 1952

Grade	White Eggs Candlers		Brown Eggs Candlers	
	R	M	G	S
Jumbo A	12	0	0	0
Large A	108	108	300	408
Large B	504	456	288	180
Medium A	12	12	36	24
Small A	0	0	0	0
Grade C	48	108	60	84
Checks	26	32	33	24
Bloods	10	4	3	0
Total	720	720	720	720

Initial Candler: white eggs R, brown eggs S

Test No. 3 - July 11, 1953

Grade	White Eggs Candlers		Brown Eggs Candlers	
	R	M	G	G
Jumbo A	12	0	0	0
Large A	192	348	432	408
Large B	372	228	120	168
Medium A	48	36	60	60
Small A	24	12	12	0
Grade C	36	48	72	36
Checks	21	47	19	46
Bloods	15	1	5	2
Total	720	720	720	720

Initial Candler: white eggs M, Brown eggs S

TABLE II (Continued)

Test No. 4 - Aug. 22, 1952

Grade	White Eggs Candlers		Brown Eggs Candlers	
	R	Y	Z	Z
Jumbo A	12	12	0	0
Large A	288	384	492	444
Large B	276	168	84	120
Medium A	24	60	60	72
Small A	12	24	12	0
Grade C	60	12	72	72
Checks	37	54	0	12
Bloods	11	6	0	12
Total	720	720	720	720

Initial Candler: white eggs M & R, brown eggs Z

Test No. 5 - Oct. 9, 1952

Grade	White Eggs Candlers		Brown Eggs Candlers	
	R	L	B	S
Jumbo A	36	24	0	0
Large A	180	300	336	396
Large B	276	192	120	24
Medium A	60	84	168	144
Small A	24	0	12	96
Grade C	120	72	48	48
Checks	19	33	36	12
Bloods	5	15	0	0
Total	720	720	720	720

Initial Candler: white eggs L, brown eggs S

Test No. 6 - Nov. 5, 1952

Grade	White Eggs Candlers		Brown Eggs Candlers	
	R	N	B	S
Jumbo A	24	24	0	0
Large A	204	444	312	456
Large B	300	36	132	72
Medium A	84	96	168	72
Small A	12	12	12	0
Grade C	72	72	60	96
Checks	22	24	34	24
Bloods	2	12	2	0
Total	720	720	720	720

Initial Candler: white eggs R, brown eggs S

TABLE II (Continued)

Test No. 7 - Jan. 28, 1953

Grade	White Eggs Candlers R	N	Brown Eggs Candlers B	T
Jumbo A	0	12	0	0
Large A	276	228	444	516
Large B	240	168	72	108
Medium A	24	12	12	36
Small A	0	0	0	0
Grade C	120	276	132	36
Checks	51	22	55	23
Bloods	9	2	5	1
Total	720	720	720	720

Initial Candler: white eggs R, brown eggs s

Test No. 8 Mar 26, 1953

Grade	White Eggs Candlers R	E	Brown Eggs Candlers B	S
Jumbo A	12	0	0	0
Large A	192	84	600	468
Large B	336	336	24	84
Medium A	48	24	24	24
Small A	0	0	0	0
Grade C	96	240	48	84
Checks	32	29	21	54
Bloods	4	7	3	6
Total	720	720	720	720

Initial Candler: white eggs R, brown eggs B

Test No. 9 - April 30, 1953

Grade	White Eggs Candlers R	E	Brown Eggs Candlers B	S
Jumbo A	60	48	0	0
Large A	468	408	528	456
Large B	84	108	0	72
Medium A	24	60	72	48
Small A	0	0	0	0
Grade C	24	60	84	108
Checks	48	31	33	24
Bloods	12	5	33	24
Total	720	720	720	720

Initial Candler: white eggs E, brown eggs S

TABLE II (Continued)

Test No. 10 - June 3, 1953

Grade	White Eggs		Brown Eggs	
	Candlers		Candlers	
	R	E	B	J
Jumbo A	24	48	0	0
Large A	432	360	504	372
Large B	60	108	48	60
Medium A	24	60	36	72
Small A	0	0	0	0
Grade C	120	96	72	36
Checks	40	37	52	179
Bloods	20	11	8	1
Total	720	720	720	720

Initial Candler: white eggs R, brown eggs B

Test No. 11 - July 1, 1953

Grade	White Eggs		Brown Eggs	
	Candlers		Candlers	
	R	E	B	B
Jumbo A	24	36	0	0
Large A	480	348	528	540
Large B	84	144	36	24
Medium A	24	36	48	36
Small A	0	0	0	0
Grade C	96	120	72	84
Checks	9	31	31	34
Bloods	3	5	5	2
Total	720	720	720	720

Initial Candler: white eggs E, brown eggs B

Test No. 12 - Aug. 1953

Grade	White Eggs		Brown Eggs	
	Candlers		Candlers	
	R	X	B	J
Jumbo A	12	12	0	0
Large A	216	348	504	276
Large B	216	72	36	216
Medium A	48	60	48	48
Small A	0	12	0	0
Grade C	144	168	72	120
Checks	67	46	56	55
Bloods	17	2	4	5
Total	720	720	720	720

Initial Candler: white eggs R, brown eggs B

VARIATION IN THE GRADING OF IDENTICAL SAMPLES OF EGGS BY DIFFERENT CANDLERS

Tables I and II reveal that in the grading of identical samples of eggs there was considerable variation between the candlers in the number of eggs placed into the various grades. There was also considerable diversity between the original grading and the second grading of eggs by the same individual. The variation in results described in the above tables was a result of the variation between candlers and also variation between sizing machines.

In grading the eggs, the candler first held the egg up to a candling lamp and then rotated it back and forth to examine the interior quality of the egg and determine whether it was an A, B, C, Check, or inedible egg. The grade A and grade B eggs were placed on a sizing machine which mechanically separated them into jumbo, large, medium, or small size classifications.

Thus in order to determine the accuracy of the work of the candlers, it was necessary to disregard size and consider the quality grade only. For example, Table III shows the eggs grouped according to the quality grades with no regard for size. The 106 eggs classified as grade A by candler "S" includes all jumbo, large, medium and small size grade A eggs.

Table III

The Number of Eggs Placed in the Various Grades by Three Candlers

Grade	Candlers S	Candlers L	Candlers N
A	106	404	262
B	492	208	366
C	77	76	67
Cks.	31	22	21
Blds.	6	10	4
Total	712*	720	720

Source: Table I - (test 2) *720 less 8 broken.

The Chi-square method of analysis was selected to study the data, since it could be considered as attributes or enumerative data. This method of analysis makes it possible to determine whether or not the difference in grading between candlers was the result of chance.

The Chi-square method of analysis was used to test the hypothesis that: there was no difference in the candling of identical samples of eggs by the selected candlers. In deciding to accept or reject any hypothesis a value must be selected, so that if the probability of an occurrence is less than the selected value, the hypothesis is rejected. The selected value for determining the acceptance or rejection of the hypothesis is called the "level of significance", and throughout this study the 05% level of significance will be used in accepting or rejecting a hypothesis. Accepting a hypothesis at the 5% level of significance means that hypotheses might be wrong once in twenty times as a result of chance in the sampling.

Chi-square values for the 12 tests on variability between candlers grading identical samples of eggs at Plant No. 1 are given in Table IV. All the Chi squares were highly significant with 8 degrees of freedom at the 05 and 01% levels ("P" values 16.919 and 21.666 with 8 degrees of freedom at the 05 and 01% levels). Since all of the Chi square values are greater than these "P" values, the hypothesis that there is no difference between these candlers in the grading of identical samples of eggs has to be rejected.

Table IV

Chi Square Values of Twelve Tests of the Variability in the Grading of Identical Samples of Eggs By Different Candlers

Test	Chi Square Values	
	White Eggs	Brown Eggs
1	789.0	120.4
2	292.9	48.8
3	439.2	328.7
4	144.3	510.4
5	228.0	786.7
6	458.8	316.4
7	301.6	460.5
8	88.4	1334.8
9	311.9	186.4
10	109.7	546.4
11	267.4	467.4
12	123.8	544.2

Source: Table I

All the Chi square values from the tests at Plant No. 2 were also highly significant and it was necessary to reject the hypothesis on the basis of the tests conducted at Plant No. 2. The smallest Chi square computed in the 12 tests at Plant No. 2 was 19.28. This value is highly significant even at the 01% level. Chi square values in this test would be significant if larger than 9.488 at the 05% level and 13.277 at the 01% level with 4 degrees of freedom.

VARIATION IN GRADING BY THE INDIVIDUAL CANDLER

In each test the candler graded two cases of 360 eggs each. The grading of the two cases by each candler was found to be fairly consistent. Since both cases were candled within a short period of time, these tests do not give any indication of the possibility of disparity in egg candling due to the effect of the time of day or the fatigue of the worker.

In each of the tests the sample was made up of eggs that had been previously candled by one or more of the candlers being tested. The results of the tests in which the candler graded the same eggs twice are shown in Table V through Table VIII. For example, Table V shows that on 4 of the tests, eggs that had been candled by candler "L" was used. According to the original grading by this candler there were 360 grade A, 240 grade B, and 120 grade C eggs in each test sample. The figures under the column headed "Second grading" indicate the number of these eggs this same candler placed in the various grades when she graded the eggs the second time. Eggs initially candled by Candler "N" were used for two test samples, and two test samples composed of eggs initially candled by Grader "C". One test sample came from Candler "I" and one from Candler "S". The other 2 test samples at Plant No. 1 were composed of eggs from all three candlers. These tables (V - VIII) disclose the difference between the first and second grading of the same eggs by the same candler.

In 22 of the 42 tests in which candlers graded the same eggs a second time, they placed more eggs in the grade A class on the second grading than they did on the initial grading. Five of the tests were from Plant No. 1 and 17 from Plant No. 2. Seven of the 22 tests in which the eggs were upgraded on the second test were white egg samples and 15 were brown egg samples. Brown egg Candler "X" (Table VI) placed more eggs in the grade A class on the second grading each of the four times that her eggs were used in the test samples. In every test except one all the brown egg candlers tested at Plant No. 2 placed more eggs in grade A class on the second grading than on the initial grading. The white egg candlers at Plant No. 2 (Table VII) also tended to "up-grade" the eggs.

In 19 of the 42 tests, the candlers classified more eggs as grade B on the second grading than on the first grading. Fourteen of these tests were at Plant No. 1 and only 5 at Plant No. 2. Thirteen were white egg tests and only six were brown egg tests.

In 38 out of 42 tests there were fewer grade C eggs on the second grading. The four tests with more grade C eggs on the second grading than on the initial grading were white egg tests at Plant No. 2. (Table VII).

These data indicate there is considerable inconsistency in the grading of identical eggs by the same candler. There appears to be considerable variation from day to day in what the individual candler considers a grade A, B, or C egg. In making comparisons between the first and second grading there is a time factor to be considered. There was a time lapse of 12 to 24 hours between the first and second candling which might influence the interior quality of the eggs. However, it has been generally assumed that an egg deteriorates with age, but in these tests there were indications of an "up-grading" on the second grading. This was particularly true in the brown eggs.

TABLE V

Initial and Second Grading of Test Samples of White Eggs by the Same Candler, Plant No. 1

Candler	Grade	Initial Grade	Second Gradings			
L	A	360	404	267	342	120
	B	240	208	334	273	523
	C	120	76	87	79	56
N	A	360	208	234		
	B	240	383	372		
	C	120	105	100		
O	A	360	269	169		
	B	240	333	415		
	C	120	89	101		
I	A	360	239			
	B	240	383			
	C	120	55			
S	A	360	0			
	B	240	666			
	C	120	33			

TABLE VI

Initial and Second Grading of Test Samples of Brown Eggs by the Same Candler, Plant No. 1

Candler	Grade	Initial Grade	Second Gradings			
X	A	360	511	466	520	614
	B	240	122	200	86	59
	C	120	50	42	94	27
G	A	360	248	200	245	
	B	240	321	433	364	
	C	120	103	66	70	
E	A	360	112			
	B	240	447			
	C	120	104			
F	A	360	98			
	B	240	492			
	C	120	97			

TABLE VII
Initial and Second Grading of Test Samples of White Eggs by the Same Candler, Plant No. 2

Candler	Grade	Initial Grade	Second Gradings						
R	A	360	444	132	324	300	252	480	276
	B	240	180	504	300	240	336	60	216
	C	120	60	48	72	120	86	120	144
E	A	360	516	420					
	B	240	108	144					
	C	120	60	120					
L	A	360	408						
	B	240	192						
	C	120	72						
M	A	360	396						
	B	240	228						
	C	120	48						

TABLE VIII
Initial and Second Grading of Test Samples of Brown Eggs by the Same Candler, Plant No. 2

Candler	Grade	Initial Grade	Second Candling				
S	A	360	288	432	636	528	504
	B	240	336	180	24	72	72
	C	120	84	84	48	96	108
B	A	360	624	540	576	576	552
	B	240	24	48	36	24	36
	C	120	48	72	72	84	72
Z	A	360	564	516			
	B	240	84	120			
	C	120	72	72			

VARIATION DUE TO SIZING MACHINES

The variation in the number of eggs placed in each of the grades was due in part to the candlers and part to sizing machines. It was impossible to analyse the variation in the data in Tables I and II due to the sizing since the grade C eggs were not put through the sizing machines. Any grade C eggs on first grading which were graded A or B quality on the second grading would be graded for size on the second grading. Changing the quality grade in the second grading could thus have considerable influence on the sizing operation.

An analysis of the variation in the number of eggs placed in the size and quality grades (Table IX) by the different candlers and sizing machines showed significant differences. This was to be expected, since the variation between candlers in determining the interior quality grades, which is part of the total variation, was found to be highly significant.

Table IX

Distribution By Grades of Identical Samples of Eggs Candled By Different Candlers

Grade	Candlers		
	S	L	N
Jumbo A	2	42	6
Large A	104	326	250
Medium A	0	36	6
Small A	0	0	0
Large B	484	198	343
Medium B	8	10	23
Grade C	7	76	67
Checks	31	22	21
Other	0	2**	0
Bloods	6	8	4
Total	712*	720	720

Source: Table I, Section B. *8 leakers, **1 rot and 1 stuck yolk.

JUMBO, MEDIUM, AND SMALL EGGS

According to the initial grading each test sample contained 360 grade A-Large, 240 grade B-Large, and 120 grade C eggs of assorted sizes, but Tables I and II reveal that on the second grading there was a considerable number of the A and B eggs classified as Jumbo, Medium, and Small. This could have been due to discrepancy between the sizing machines, or these eggs rated as Jumbo, Medium, and Small could have been eggs that were originally classified as grade C and were reclassified as grade A or B in the second grading. The latter probably accounts for most of the Jumbo, Medium, and Small eggs found in the tests where the eggs were size graded the second time by the same machine. It is possible but highly improbable that a machine would vary this much in the sizing of eggs from one day to the next, although there might be some inconsistencies due to changes in temperature and humidity.

BLOOD AND MEAT SPOTS

Some eggs with blood and meat spots were found on the second grading that were apparently missed on the first grading. The number of eggs with blood or meat spots found on the second grading at Plant No. 1 (Table I) varied from zero to 49 (white eggs 0-25, brown eggs 0-49) in each test sample. More brown eggs with meat or blood spots were found on the second grading than were discovered in the white eggs. The average number of "bloods" per sample of white eggs was 5.6 eggs and in the brown egg samples it was 7.8 eggs. Three white eggs and 21 brown eggs were classified as rots on the second grading. Slightly more brown eggs than white eggs were classified as "dirty" in the second grading of the test samples.

At Plant No. 2 the number of eggs with blood or meat spots found on the second grading varied from zero to twenty with an average of 5.3 blood eggs per sample in the white eggs and 3.1 blood eggs per sample in the brown eggs. The white egg candlers at Plant No. 2 found more "bloods" on the second grading than the brown egg candlers, which was just the opposite to the findings at Plant No. 1.

CHECKS AND LEAKERS

The number of "checks" found on the second grading was rather constant. The "checks" could have been a result of the original grading and packing, or the rehandling involved in setting up the test cases. The number of checked eggs per test sample varied from 5 to 51 at Plant No. 1. The average was 19.1 checked eggs in each white egg test sample and 21.3 checked eggs in each of the brown egg test samples. (Table I). A few eggs were broken (leakers) in the test samples. Ten "leakers" were the most broken eggs found in any one test sample.

The number of checks detected in the test samples at Plant No. 2 varied from 0 to 179 per sample. The average number of checks per sample was 33.6 in the white eggs and 37.9 in the brown eggs (Table II). More checks were found in the test samples at Plant No. 2 than at Plant No. 1.

GRADE C EGGS

The number of eggs classified as grade C eggs in identical samples of eggs by the different candlers in 12 tests at Plant No. 1 is shown in Table X. A total of 14 candlers (8 white egg candlers and 6 brown egg candlers) were tested. In all tests except four there were fewer eggs placed in grade C (less than 120) on the second grading than were placed in this classification by the candlers in the original grading.

The number of eggs placed in C grade by the candlers at Plant No. 2 is shown in Table XI. Thirteen candlers (7 white egg and 6 brown egg candlers) were tested at this plant. Only nine of the 48 samples contained more grade C eggs on the second grading than on the first grading. Undoubtedly, a number of the checks found on the second grading came from the C grade eggs, since some thin or weak shelled eggs were classified originally as grade C eggs.

In order to ascertain if there was a difference between candlers in the number of eggs classified as grade C, the various "blocks"* of grade C eggs within the tables were tested. The "F" test was used in analysing the variance between three candlers. In comparing the variation in grading of eggs by two candlers "paired comparisons" with the "t" test was used. It was assumed that this arrangement of the data could be considered as "continuous data", since there were 720 eggs in each sample. Examples of the method used in this statistical analysis can be found in the appendix (2 and 3).

Significant differences were found between the candlers in the number of eggs classified as grade C eggs. The "F" and "t" values

*The tests in which the same candlers participated.

were significant in all the "Blocks" tested except white egg candlers S, L, and N. Although there was a significant difference between candlers L. O, and N, there was no significant difference between candlers L, N, and S. Candlers L and N did not differ significantly when tested together.

The "t" values computed from the "blocks" in Table XI (Plant No. 2) were insignificant, but all of these blocks were small. With small sized "blocks" it requires a rather large "t" value to be significant. When the grading of Candler R was compared with all the other white egg candlers (Table XI), no significant difference was detected between this candler and the others.

TABLE X
Number of Eggs from Identical Samples Classified as Grade C by Different Candlers in each of 12 Tests between April, 1952 and August, 1953, Plant No. 1

(White Eggs)

Test No.	S	L	N	O	K	V	C	I
1	33	41	21					
2	77	76	67					
3	42	31	105					
4	25	77	40					
5		82	75		75			
6		87	125	81				
7		99	100	46				
8		74	112	89				
9		79	109	92				
10				101		83		25
11				91			102	55
12	56					72	55	

(Brown Eggs)

Test No.	C	T	E	X	G	F
1	85			50	34	
2		104		38	103	
3			106	56	87	
4			51	25	90	
5			127	21	46	
6			165	42	37	
7			56	22	66	
8			104	23	57	
9			129	94	103	
10				51	70	84
11				66	43	97
12			65	27	25	

Source: Table I

TABLE XI

Number of Eggs from Identical Samples Classified as Grade C by Different Candlers in each of 12 Tests between April, 1952 and August, 1953, Plant No. 2

(White Eggs)

Test: No.:	M	R	Y	L	N	E	X
1 :	24	60					
2 :	108	48					
3 :	48	36					
4 :		60	12				
5 :		120		72			
6 :		72			72		
7 :		120			276		
8 :		96				240	
9 :		24				60	
10 :		120				96	
11 :		96				120	
12 :		144					168

(Brown Eggs)

Test: No.:	G	S	B	T	J	Z
1 :	48	84				
2 :	60	84				
3 :						
4 :						
5 :		48	48			
6 :		96	60			
7 :			132	36		
8 :		84	48			
9 :		108	84			
10 :			72		36	
11 :						
12 :			72		120	

Source: Table II

GRADE B EGGS

The number of eggs classified as grade B by the various candlers on the twelve tests at Plant No. 1 is shown in Table XII. Of the 72 test samples, 48 samples had more grade B eggs on the second grading than in the initial grading. Thirty-one of these were white egg samples and seventeen were brown egg samples. While the samples contained 240 grade B eggs according to the first grading, the number of grade B eggs per sample found on the second grading ranged from 188 to 666 in the white eggs and 28 to 560 in the brown eggs.

When analysing the variance between the number of grade B white eggs found by the different candlers on the second grading, the values computed were not significant, but the "F" and "t" values in all the brown egg "blocks" were significant. The hypothesis that - there was no difference between candlers in the number of eggs rated as grade B has to be accepted for the white egg candlers and rejected for the brown egg candlers.

Ten of the white egg and two of the brown egg samples of the 48 samples at Plant No. 2 had more grade B eggs on the second grading than in the original grading (Table XIIV). The number of grade B eggs found in the test sample on second grading varied from zero to 504 (white eggs 36-504, brown eggs 0-336). When the number of eggs classified as grade B by Candler R (Table XIII) was compared with all the other candlers, no significant difference was found.

TABLE XII

Number of Eggs from Identical Samples Classified as Grade B by Different Candlers in each of 12 Tests between April, 1952 and August, 1953, Plant No.1

(White Eggs)

Test No.	S	L	N	O	K	V	C	I
1	666	285	201					
2	492	208	366					
3	263	188	383					
4	274	415	406					
5		227	360		488			
6		334	512	625				
7		263	372	393				
8		328	229	333				
9		273	416	546				
10				415		447		364
11				520			258	383
12		523				370	349	

(Brown Eggs)

Test No.	C	T	E	X	G	F
1	206			122	288	
2		270		89	321	
3			54	28	36	
4			204	141	471	
5			445	89	414	
6			365	200	282	
7			331	89	433	
8			447	147	174	
9			265	86	261	
10				182	364	560
11				209	189	492
12			308	59	235	

Source: Table I

TABLE XIII

Number of Eggs from Identical Samples Classified as Grade B by Different Candlers in each of 12 Tests between April, 1952 and August, 1953, Plant No. 2

(White Eggs)

Test No.	M	R	Y	L	N	E	X
	Candlers						
1	408	180					
2	456	504					
3	228	372					
4		276	168				
5		276		192			
6		300			36		
7		240			168		
8		336				336	
9		84				108	
10		60				108	
11		84				144	
12		216					72

(Brown Eggs)

Test No.	G	Z	S	B	T	J
	Candlers					
1	204		336			
2	288		180			
3						
4						
5			24	120		
6			72	132		
7				72	108	
8			84	24		
9			72	0		
10				48		60
11						
12				36		216

Source: Table II

GRADE A EGGS

The number of eggs classified as Grade A eggs in identical samples of eggs by the various candlers in 12 tests at Plant No. 1 is shown in Table XIV. There were 360 grade A eggs in each sample according to the initial grading, but on the second grading there were zero to 614 eggs classified in this category. Of the 72 test samples, 31 had more Grade A eggs on the second grading than were in the original test sample. Significant differences were found between these candlers in the number of eggs classified as Grade A eggs. In all the brown egg "blocks" tested, the computed values were significant. Among the white egg candlers, no significant difference was found between Candlers S, L, and N and between L and N.

At Plant No. 2 the number of eggs classified as grade A in the grading of identical samples ranged from 108 to 636. At this plant 21 of the 24 brown egg tests had over 360 grade A eggs on the second grading, and half of the white egg samples had more grade A eggs than the 360 placed in grade A on the original grading. No significant differences were found between graders in the determination of grade A eggs. Here again, as with the grade C and B eggs, the "blocks" in Table XV were not of sufficient size for this type of analysis.

TABLE XIV

Number of Eggs from Identical Samples Classified as Grade A by Different Candlers in each of 12 Tests between April, 1952 and August, 1953, Plant No.1

(White Eggs)

Test: No.:	Candlers S	L	N	O	K	V	C	I
1 :	0	371	469					
2 :	106	404	262					
3 :	361	471	208					
4 :	384	197	262					
5 :		382	268		177			
6 :		267	64	0				
7 :		340	234	264				
8 :		382	260	261				
9 :		342	172	63				
10 :				169		171		302
11 :				70			327	239
12 :		120				246	286	

(Brown Eggs)

Test: No.:	Candlers C	T	E	X	G	F
1 :	409			511	377	
2 :		275		544	248	
3 :			549	597	581	
4 :			444	491	136	
5 :			66	545	221	
6 :			179	466	377	
7 :			304	570	200	
8 :			112	532	464	
9 :			308	520	336	
10 :				439	245	30
11 :				399	461	98
12 :			313	614	447	

Source: Table I

TABLE XV

Number of Eggs from Identical Samples Classified as Grade A by Different Candlers in each of 12 Tests between April, 1952 amd August, 1953, Plant No. 2

(White Eggs)

Test No.	M	R	Y	L	N	E	X
1	246	444					
2	120	132					
3	396	276					
4		336	480				
5		300		408			
6		324			576		
7		300			252		
8		252				108	
9		552				516	
10		480				468	
11		528				420	
12		276					432

(Brown Eggs)

Test No.	G	Z	S	B	T	J
1	420		288			
2	336		432			
3						
4						
5			636	516		
6			528	492		
7				456	552	
8			492	624		
9			504	600		
10				540		444
11						
12				552		324

Source: Table II

INFLUENCE OF VARIATION IN GRADING ON PRODUCER PAYMENTS

In order to determine the influence that the variations in (1) the grading of identical samples of eggs by different candlers, (2) the same sample by the same candler at different times, (3) and different sizing machines had upon the payments made to producers, the number of eggs placed in the different grades in the test samples were converted to monetary values. The average yearly price for each of the different grades was used to compute the value of the number of eggs in each grade of the test samples. The following table gives the average yearly price paid for each grade of eggs at the two plants during the period the tests were conducted.

Table XVI

The Average Yearly Price Paid Producers For Eggs by Plant, Grade and Color of Eggs
(Cents per Dozen)

Grade	Plant No. 1		Plant No. 2	
	White Eggs	Brown Eggs	White Eggs	Brown Eggs
Jumbo A	57.44	55.19	51.19	51.19
Large A	53.83	52.10	47.87	45.38
Medium A	46.38	45.27	40.19	39.37
Small A	36.38	36.38	30.54	30.44
Large B	47.37	46.33	41.52	39.87
Medium B	38.29	38.29	-	-
Grade C	27.44	27.44	32.35	32.35
Checks	27.44	27.44	27.92	27.92

The value per case (30 dozen) of each of the test samples is shown in Tables XVII and XVIII. The difference between the highest and lowest value on each of the tests at Plant No. 1 varied from 1¢ to $2.18 per case. At Plant No. 2 the range in value was from 7¢ to 91¢ per case, but there were just two candlers in each of the tests at Plant No. 2. The average difference between the values was 59.9¢ per case, or about 2¢ per dozen.

The variation in the grading was reduced to one value by converting the grading of the test samples to the monetary value, but the prices of the different grades had considerable influence on the value. For example, comparing the white egg prices, there is a 20¢ per dozen difference between the Jumbo A price and the grade C price, but there is less than 1¢ per dozen difference between the grade A medium eggs and the Grade B large eggs.

Significant differences as well as non-significant differences were found in testing the variation among candlers of the various blocks within Table XVI. The "blocks" of candlers within Table XVII were too small to provide an effective test.

TABLE XVII

The Value per Case of the Identical Test Samples Based on the Grading of the Individual Candlers, Plant No. 1

(White Eggs)

Test No.	Candlers S	L	N	K	O	I	V	C
1	$13.59	14.56	14.86					
2	13.31	14.20	14.01					
3	13.60	14.32	13.34					
4	14.01	13.41	14.88					
5		13.78	13.23	13.38				
6		13.78	13.04		13.32			
7		13.90	13.77		14.15			
8		14.03	13.65		13.79			
9		14.07	13.40		13.28			
10					13.39	14.46	13.69	
11					13.16	13.15		13.50
12		13.71					13.63	14.13

(Brown Eggs)

Test No.	Candlers C	T	E	X	G	F
1	$13.92			14.18	14.06	
2		12.81		14.14	12.86	
3			14.14	14.15	14.32	
4			13.78	13.87	12.99	
5			11.55	13.73	13.00	
6			12.78	14.51	13.82	
7			13.80	14.59	13.57	
8			12.61	14.70	14.20	
9			13.38	14.21	13.48	
10				13.95	13.46	12.79
11				13.87	14.23	12.95
12			13.46	14.35	14.29	

Source: TableI

TABLE XVIII

The Value per Case of the Identical Test Samples Based on the Grading of the Individual Candlers, Plant No. 2

(White Eggs)

Test: No.:	Candlers M	R	Y	L	N	E	X
1 :	13.06	12.91					
2 :	12.07	12.28					
3 :	12.84	12.36					
4 :		12.57	12.92				
5 :		12.79		12.58			
6 :		12.56			13.01		
7 :		12.27			11.88		
8 :		12.37				11.46	
9 :		12.36				13.21	
10 :		12.65				12.81	
11 :		13.34				12.79	
12 :		11.83					12.40

(Brown Eggs)

Test: No.:	Candlers G	Z	S	B	T	J
1 :	$12.35		12.27			
2 :	12.25		12.51			
3 :						
4 :						
5 :			12.61	12.32		
6 :			12.58	12.21		
7 :				12.21	12.90	
8 :			12.40	13.03		
9 :			12.34	12.68		
10 :				12.49		11.78
11 :						
12 :				12.54		11.86

Source: Table II

SUMMARY

The objectives of these tests was to detect the variation that existed between candlers in the grading of identical samples of eggs, and the influence that this variation had upon the payments received by producers, when the eggs were marketed on a graded basis. The tests were made in order to point out the variation in the average price that producers receive for eggs due to the variation in grading methods now in use, and to compare them with other methods of grading that might be developed and that would be more efficient.

1. These tests (Tables I and II) indicate that there is considerable variation in the grading of identical samples of eggs by different candlers. The candling of the eggs for interior quality and the sizing operations are both sources of this variation.

2. A total of 27 candlers were tested and the differences between candlers in all 48 of the tests were found to be highly significant. The hypothesis that "there were no differences between candlers in the grading of eggs" had to be rejected. The amount of variation in the sizing of identical samples of eggs by different sizing machines was not determined.

3. There also was considerable variation in the candling of the same eggs twice by the same candler. Although there was a time lapse of 12 to 24 hours between the first and second grading, which presumably results in lower quality, the tests gave indication of upgrading of the eggs between the first and second grading. More eggs were actually placed in the A grade and less in the C grade on the second grading than on the first grading.

4. The divergence in grading within the various quality grades appeared to be about the same. There was as much variation between candlers in the classification of grade C eggs as there was in the classification of grade B or grade A eggs.

5. The payment to producers based on the grading of identical test samples of eggs varied from 1¢ to $2.18 per case depending upon which candler graded the eggs. The average difference was 59.9¢ per case, or 2¢ a dozen.

SAMPLING IN DETERMINING GRADES AS A BASIS FOR PRODUCER PAYMENT

REVIEW OF LITERATURE

A number of procedures and methods have been proposed or developed to increase efficiency in the marketing of eggs on a "graded basis." In 1932 the Canadian Department of Agriculture[1] published a pamphlet describing a method of keeping "stop and start" counts on the number of eggs in each grade for computing returns to producers selling eggs on a graded basis. The objective of this method was to reduce the time required to record the grade of each producer's eggs.

It was found in a survey conducted in Minnesota[2] that a maximum of three grade classifications were used in buying eggs from producers, but there was considerable variation among the handlers in the requirements and terms used to describe the grades. This situation was very confusing to the producers and it was suggested that a more simplified standard be developed with "Uniform Purchase and Consumer Grades". The plan combined some of the many grades of the U.S. Standards into four grades. The grades suggested were:

1. Grade A Large - shall consist of eggs which are of U.S. quality A or better. The minimum net weight per dozen shall be 24 ounces and the minimum weight for individual eggs shall be 23 ounces.

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1 The Individual Graded Return, Ottawa, Canada, Dominion of Canada Department of Agriculture, Pamphlet No. 70, 1932.

2 Dankers, W.H., "Lack of Uniformity in Egg Grades at the Producer and Consumer Levels," Paper presented at Poultry Science Association Meeting, Fort Collins, Colorado, 1948.

2. Grade A Medium - shall consist of eggs which are of U.S. quality A or better. The minimum net weight per dozen shall be 21 ounces and minimum weight for individual eggs shall be 20 ounces.

3. Grade B Large - shall consist of eggs which are of U.S. quality B. The minimum net weight per dozen shall be 24 ounces and the minimum weight for individual eggs shall be 23 ounces.

4. Grade C - shall include all edible eggs not included in grades A, large and medium, and grade B, large including checks, stains, and dirties.

This plan would not only simplify the grading programs for producers and consumers, but it would also reduce the cost of computing payments to producers.

California workers[1] have developed a system to eliminate expensive detailed candling, multiple grade recording, and price calculations. This system was based on the results of a three year study which shows the various grades have a consistent value relationship in the Los Angeles market. The values were converted to market value points with Grade A Large equal to one point, and the point values of the other grades were determined on the basis of the relation of the price of the various grades to the price of Grade A large, as follows:

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1 Sanborn, Lynn D., Paying Producers According to the Value of Eggs Shipped, Agricultural Extension Service, Los Angeles, California, 1951.

Grade	Points Assigned
AA	1.1
A	1.0
B	.8
C	.6
Stained	.8
Checked	.8
Dirties	.6
Loss	.0

Each month a sample of large eggs is graded at each farm by the U.S.D.A. Grading Service. The grader determines the per cent of eggs in each of the above grades. Each of the percentages are multiplied by the correct assigned point value. The resulting values are added to determine the total value score for each producer. For example, if a grader's sample contained 35% A, 50%AA, 2.5% B, 0.5% stained, 3% checked, 3% C, 3.5% dirty, and 2.5% loss, the producer would have a value score of 98.7. The following table shows how this value is determined.

Grade	Per Cent of eggs in each grade	X	Point Values	=	Value Score
AA	50.0		1.1		55.0
A	35.0		1.0		35.0
B	2.5		.8		2.0
C	3.0		.6		1.8
Stained	0.5		.8		.4
Checked	3.0		.8		2.4
Dirty	3.5		.6		2.1
Loss	2.5		.0		---
Total	100.0				98.7

A value score of under 100 means that the eggs are worth less than grade "A" eggs. Eggs delivered between each monthly test are paid on the basis of the latest computed egg value scores.

This method of paying producers for eggs on a quality basis appears to have considerable merit. The question of egg size and time interval between samples needs further study before being applied to other areas.

California workers[1] tried a method of paying producers on the basis of the per cent of AA quality eggs produced. This method was found to be inadequate because it did not give the true value of the eggs. One could have a high percentage of AA quality eggs and also have a relatively high percentage of checks, inedibles, and C grade eggs. In other words, one poultryman might have 80% AA quality eggs but have enough of the lower qualities so that his shipment would not be as valuable as another shipment with 75% AA quality eggs, but a lower percentage of checks, dirties, and inedibles.

In order to reduce the cost of computing payments to producers, the Washington Co-operative Farmer Association[2] has developed a program entitled "Certi-Best." In this program more emphasis is placed on grading the producer and less on the grading of his eggs. It is patterned after the dairymen's Grade A milk program.

In order to qualify for the program the producer must meet the

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[1] Correspondence, L.D. Sanborn, Farm Advisor, Los Angeles County Extension Service, Los Angeles, California, Nov. 5, 1951.

[2] Correspondence, Harry J. Beernink, Washington Co-operative Farmers Association, Seattle, Washington, Oct. 31, 1951.

following qualifications.[1]

1. Only pullet flocks are used.
2. A definite feeding program is required. Must feed laying mash and no green feed or yellow corn in excess of a specified amount.
3. Flocks laying high per cent of blood spots are not accepted for the program.
4. Eggs must not be washed on the farm. Must be produced clean or cleaned by dry methods.
5. Eggs must be maintained on the farm in an approved refrigerated egg room at a temperature of 50° F.
6. Either brown eggs or white eggs are acceptable. Eggs from breed crosses of brown and white egg strains are not accepted.
7. Quality of the eggs delivered must not be more than 10% below average of all producers.

The producer who qualifies under this program will be paid on the basis of three grades - large, medium, and small, rather than a breakdown of eight to fifteen grades. In complying with the above requirements, it is expected that all the producers in the program will market high quality eggs. A record of the interior quality is not needed to compute the payments to producers.[2]

The program has considerable merit. It not only encourages larger sized units and higher quality, but it also reduces the cost of buying on a graded basis. However, it is probable that the program would only work satisfactorily in a specialized egg producing area.

The above are examples of methods and procedures that have been

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1 Correspondence, M. Wayne Miller, Washington Co-operative Farmers Association, Seattle, Washington, Dec. 6, 1951.

2 Miller, M. Wayne, "Egg Quality Program For Washington Co-operative Members," Washcoegg, Vol. 29, No. 3, August, 1951.

or are being used to reduce the cost of buying eggs on a graded basis. Another approach to the cost problem of buying eggs on a graded basis is the use of "wholesale grades." When this procedure is used, the payment to the producer is based on a sample. Van Wagenen[1] in studying the operations of New England Egg Marketing Cooperatives using wholesale grades, found there was considerable variation in the sampling methods being used by the different plants. He also found a high degree of uniformity in the quality of eggs sold from week to week by the regular shippers. The eggs were sold as well as bought on the basis of a sample. Van Wagenen concluded that for certain buyers, a check inspection on known lots appeared to be a satisfactory method of determining the value of the eggs, if used with a replacement guarantee to take care of the occasional case of very poor eggs that might get by undetected. It is not a reliable method of determining egg values, however, unless a high quality standard is maintained.

Determining the wholesale grade by candling 100 eggs in each case, together with a tolerance to cover the undetected out-of-grade eggs in the balance, appears to have been a satisfactory method of determining egg quality for most buyers.

In determining the number of defective eggs in a case by this sampling method, Van Wagenen concluded that samples of 100 eggs show average defects of 10 ± 3 eggs. If this is accepted as representative of the universe under consideration, then the standard deviations of

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1 Van Wagenen, Alfred, Grades and Prices at New England Egg Marketing Cooperative Associations, Boston, Massachusetts, The New England Research Council on Marketing and Food Supply, June, 1942.

other size samples may be calculated.

Size of Sample	Standard Deviation
10	+ or - 9.5%
20	+ or - 6.7
30	+ or - 5.5
40	+ or - 4.8
50	+ or - 4.2
60	+ or - 3.9
80	+ or - 3.4
100	+ or - 3.0

This means that if a sample of 100 eggs show 10% defects, the odds are 2 in 3 that the true percentage of defects in the whole case lies between 7 and 13%. In a sample of 40 eggs showing 10% defects, the odds are 2 in 3 that the true percentage of defects of the whole case lies between 5.2 and 14.8%. The improvement in accuracy increases very slowly as the size of the sample is increased above 40 eggs. Van Wagenen concludes from this that it might be entirely practical to use a 40 egg sample, since it is doubtful if the improvement of 2% in accuracy of a 100 egg sample is warranted in cost or justified in view of the probable sampling error.

Because of the debatable soundness of the original supposition as to the variation of the universe from which the sample would be drawn, the above study was presented as a guide for further experiments.

EXPERIMENTAL DESIGN

The second objective of this study was to investigate the possibilities of using sampling techniques to determine the quality of eggs as a basis for paying producers which would be simpler, less expensive, and as accurate as the present methods. The present method of grading each producer's eggs separately, keeping separate records for each producer on the number of eggs in each grade, and computing the total payment from the number of eggs in each of several grades at a different price for each grade is costly when done for each producer.

The sampling techniques investigated were (1) payment to producers on the basis of the grade on a one case (30 dozen) sample taken from each shipment, (2) payment to producers on the basis of the grade of a one case sample taken from one shipment for a predetermined number of following shipments, (3) payment to producers for a predetermined number of following shipments on the basis of the grade of one entire shipment.

In order to investigate these methods of payments, 66 producers (42 shipping eggs to Plant No. 1 and 24 shipping to Plant No. 2) were selected on the basis of: (1) size of shipments, (2) color of eggs, (3) consistency of shipments during previous years, (4) the probability of the producer continuing to ship eggs to the organization during the year of the study.

The size of shipments during the previous year was used as the basis in selecting the producers for size of shipments. The object was to have one third of the group market an average of less than two cases of eggs each week, one third between two and four cases, and one third over four cases of eggs each week. An attempt was also made to select one half white egg producers and one half brown egg producers. Table XIX shows the distribution of the 66 producers selected for the study.

Table XIX

The Distribution of the Producers by Size of Shipment, Color of Eggs, and Plant

Average Weekly Shipment (dozen)	White Egg Producers		Brown Egg Producers	
	Plant No. 1	Plant No. 2	Plant No. 1	Plant No. 2
Up to 60	7	4	7	4
60 - 120	7	4	7	4
120 & over	7	4	7	4
Total	21	12	21	12

Every producer shipped eggs at least 50 weeks during the previous year. Producers selling a part of their eggs to hatcheries during the previous hatching season were not included. Since records were to be kept on the eggs sold by each producer for an entire year, consideration was given to the probability of the producer continuing to market his eggs through the same organization. The plant management assisted in making the selection of the producers for this factor. In selecting the producers, no consideration was given to the type or breed of birds, size of flock, or flock management practices.

Six candlers at Plant No. 1 and four candlers at Plant No. 2 were selected to grade the eggs shipped by these producers. The candlers were selected on the basis of experience and the probability of continuing employment at the plant for the entire year. A group of producers (7 at Plant No. 1 and 6 at Plant No. 2) were randomly assigned to each of the candlers. Each group contained at least two producers from each of the size classes listed in Table XIX.

Each candler was instructed to grade all the eggs of every producer assigned to her every week during the year. The objective of this procedure was to eliminate the variation in grading between shipments due to the eggs being graded by a different candler. In order to make sure that the eggs from each producer would be graded by the same candler every week, different colored case cards and colored markings were used to help identify the shipments to be graded by the different candlers.

The candler was instructed to select one case (30 dozen) of eggs at random from each shipment and grade it separately from the rest of the shipment. A record was made of the grade of the one case sample and the grade of the entire shipment of each producer for each of 52 consecutive weeks. At Plant No. 2 the records covered the period - March 15, 1952 to March 15, 1953, and at Plant No. 1 the period of October 25, 1952 to October 25, 1953.

Out of the 66 producers selected at the start of the project, 52 producers shipped eggs almost every week during the year. Fourteen producers were dropped because they stopped marketing eggs through the plants or the records were not complete. The records were incomplete because the producer failed to ship eggs for a number of weeks or the candler failed to grade a one case sample. Table XX shows the distribution of the 52 producers used in this phase of the study.

TABLE XX
Distribution of Producers by Size of Weekly Shipments, Color of Eggs, and Plant

Average Weekly Shipment (dozen)	White Egg Producers		Brown Egg Producers	
	Plant No. 1	Plant No. 2	Plant No. 1	Plant No. 2
Up to 60	6	3	5	6
60 - 120	4	5	7	1
120 & over	7	5	2	1
Total	17	13	14	8

There was a wide variation in the average size of the weekly shipments of eggs by the different producers. In Table XXI the 52 producers are grouped by color of eggs and plant, and arrayed by average size of weekly shipment.

Table XXI

An Array of the Average Weekly Shipment of the 52 Producers by Plant and Color of Eggs

White Egg Producers		Brown Egg Producers	
Plant No. 1	Plant No. 2	Plant No. 1	Plant No. 2
(doz.)	(doz.)	(doz.)	(doz.)
24.5	27.0	21.9	37.0
36.8	42.1	34.4	40.0
50.1	48.8	41.2	45.1
54.9	63.3	51.4	45.3
55.9	74.5	58.4	49.4
56.4	75.3	62.5	58.2
62.1	75.4	63.2	82.3
63.2	112.7	64.6	200.9
76.4	125.4	67.7	
89.0	140.5	86.0	
129.7	146.0	86.5	
142.3	168.0	92.1	
151.8	169.2	145.9	
178.8		227.1	
270.6			
309.8			
322.1			

Although the project was set up so that one candler would grade every weekly shipment of eggs from 6 to 7 different producers for one year, this plan could not be followed because some of the candlers resigned or were transferred to other jobs in the plant. Other candlers had to grade the eggs when the regular candlers were on vacations.

At Plant No. 1 as many as 18 different graders candled the eggs of the selected producers during the year. The lowest number of different candlers to grade the eggs of a single producer at Plant No. 1

was six. Although it was not possible for one candler to grade every weekly shipment of eggs of an individual producer for the entire year, a fewer number of candlers were used at Plant No. 2 than at Plant No. 1.

A record was made every week of the grade of a one case sample and the grade of the total shipment of eggs of every producer. This data was used to determine the difference between the average returns per case a producer would receive for the entire shipment of eggs based on the grade of the sample and the returns based on the grading of the entire lot. The grades of each sample and the entire shipment were converted to the monetary values (Example - Appendix 4). The average yearly price for each grade of eggs at each plant (Table XXII) was used in converting the grade data to monetary values of a 30 dozen case. The average yearly price of eggs was used in making the conversion in order to eliminate the variation that would have resulted from using the week to week prices. The prices used were the average yearly price for the period covered by the project. Separate average prices were used for brown and white eggs and also for the two plants, since the prices were different and the time the project was carried on at the two plants was not the same. At Plant No. 2 the project started in March, 1952 and at Plant No. 1 the project started in October, 1952.

The candler "rounded" the number of eggs in each grade to the nearest dozen except "bloods" and "checks" at Plant No. 2. This "rounding" procedure helped to reduce the cost of computing producer payments, since it was not necessary to compute the value of units of less than a dozen. The candlers at Plant No. 1 recorded the actual number of eggs in each grade.

The procedures of: (1) having all shipments of a single producer graded by the same candler, (2) using an average yearly price, and (3) using the average value per case were followed in order to eliminate as many variables as possible. Thus, the difference between the average value per case of each shipment of eggs based on a sample and the value based on the grade of the entire lot would be entirely due to the sampling procedure being tested.

Table XXII

The Average Yearly Price Paid Producers For Eggs by Plant, Grade, and Color of Eggs

(Cents per dozen)

Grade	White Eggs		Brown Eggs	
	Plant No. 1	Plant No. 2	Plant No. 1	Plant No.2
Jumbo A	57.44	51.19	55.19	51.19
Large A	53.83	47.87	52.10	45.38
Medium A	46.38	40.19	45.27	39.37
Small A	36.38	30.54	36.38	30.44
Large B	47.37	41.52	46.33	39.87
Medium B	38.29	-	38.29	-
Grade C	27.44	32.35	27.44	32.35
Checks	27.44	27.92	27.44	25.92

STATISTICAL ANALYSIS

The data to be analysed for each producer for the year consisted of (1) the value of a one case sample, (2) the average value of one case based on the grade of the entire shipment (Appendix 4). Where the average weekly shipment of the producer was less than 45 dozen, only the value per case based on the grade of the total shipment was computed. A producer with an average weekly shipment of less than 45 dozen would market less than 30 dozen a week for a considerable part of the year. The value per case based on the grade of a one case sample was not computed for 12 of the 52 producers for this reason. The average weekly shipment of nine producers was less than 45 dozen and the candlers failed to grade a one case sample for three producers.

The statistical analysis was applied to the differences between the values per case based on the actual grade of the shipment and the value based on the grade of a sample.

The method of "paired comparisons" with the "t" test was used in analysing these data. The first step in the analysis was to compute the differences between the value per case based on a sampling method and the value based on the grade of the entire shipment each week during the year. Each weekly shipment afforded a basis for the use of "paired comparisons." Next, these differences were totaled and divided by the number of comparisons. This gave the mean of the differences or the mean difference for the year. It was assumed that these data could be considered as "continuous" data and these differences were normally distributed.

Thus, the hypothesis to be tested was: the mean of the differences equals zero, or stating it another way - a producer over the period of an entire year would neither be overpaid or underpaid for his eggs, if the payments were made on the basis of a sample as compared with the payments based on the complete grading of each shipment. The overpayments would be equal to the underpayments over a period of one year.

The next step in testing the hypothesis that the mean difference is zero was to determine the probability of the computed mean differences by the "t" test. The hypothesis is accepted or rejected on the basis of this value.

Using this method of analysis all sampling procedures or techniques are subject to two kinds of error: (1) Bias error - a consistent tendency to either overestimate or to underestimate the amount paid the producer for each shipment, so that over the one year period the producer is either overpaid or underpaid, (2) Random error - on each individual shipment the producer may either be overpaid or underpaid when a sampling method is used, but over the one year period the overpayments will offset the underpayments, so that in the long run the producer will neither be overpaid or underpaid.

The "t" tests will indicate whether or not a bias error exists when using a sampling technique in determining producer payments for a one year period. Even though several sampling techniques tested are found to be unbiased for the one year period, the amount of the overpayments or underpayments on the individual shipments may be so large that the sampling procedure would not be practical to use.

One measure of the variation between payments based on a sample and payments based on the complete grade would be the range between the largest overpayment and the largest underpayment. In using the range as a measure of variation, the infrequency of the occurrence of the extreme values limits the effectiveness of this measure.

Another measure of variation is the mean, but since the theoretical mean is zero this measure is not applicable.

An index of the size of these over and underpayments for a single shipment is the standard deviation of the differences. In a normally distributed population, the mean $\mp$ one standard deviation contains about two-thirds (68.27%) of the items. For example, approximately one-third of the time a producer will be overpaid on a single shipment by an amount equal to or less than the standard deviation, and one-third of the time the producer will be underpaid by an amount equal to or less than the standard deviation. This percentage will vary to some extent for random samples drawn from a normal population.

The sampling method should provide for a small enough standard deviation that the amount of the over or underpayment on a single shipment is not too large. The specific amount of the standard deviation selected in accepting or rejecting a sampling method must be an arbitrary decision and would have to be made by the plant considering the use of one of these sampling techniques.

BASING PAYMENTS TO PRODUCERS ON A 30 DOZEN SAMPLE (ONE CASE)

One Case Sample Every Week (Method A) The first sampling technique tested in this project was basing the payment for the entire shipment on the grade of a one case (30 dozen) sample of the eggs. The one case sample was selected at random from each weekly shipment during the year, and a separate record was made of the grade of this sample. The value per case based on the grade of the one case sample was compared with the average value per case based on the grade of the entire shipment. The 30 dozen eggs in the sample were all from one case and the size (30 dozen) of the sample was the same for all shipments regardless of the size of the entire shipment.

Although a 30 dozen sample composed of eggs selected from all the cases in a shipment might be more representative of a shipment than all the eggs in one case, it would require much more labor to make up the sample and for that reason would be impractical. The purpose of using a one case sample from each shipment regardless of size was to determine the maximum size of a shipment for which a one case sample would be representative of the entire lot. Although samples of various sizes (larger and smaller than 30 dozen) should be considered in developing a sampling procedure for buying eggs on a graded basis, this project was limited to a 30 dozen sample.

A one case sample was taken of each weekly shipment during the year from each of 40 producers. Not all producers shipped the entire 52 weeks of the year nor was the one case selected for each of the 52 weeks for all of these 40 producers. There were instances in which the producer failed to make a shipment for several weeks or the candler failed to take the 30 dozen sample.

The 40 selected producers are arrayed in Table XXIII according to the size of the average weekly shipment during the year. All of the statistical values pertaining to the eggs sold by these producers, including mean differences, "t" values, probabilities, and standard deviations are presented in the following tables in the same arrangement or order as in Table XXIII. The means of the differences between the value per case based on the grade of a one case sample and the value per case based on the grade of the entire shipment are shown in Table XXIV (Section a). This value is computed for each producer by subtracting the average value per case based on the sample from the average value per case based on the grade of the entire shipment. These differences are totaled and divided by the number of shipments. The mean differences are arranged in the same order as in Table XXIII. Twenty of the mean differences were negative and twenty were positive. If the 40 producers had been paid on the basis of the one case sample, half of them would have been slightly overpaid and the other half slightly underpaid. The negative values indicate overpayments and positive values indicate underpayments would have been made to the producers if the sample had been used as the basis of payments.

With the hypothesis that the mean difference of the population was zero, what was the probability of finding the mean differences in Table XXIV? To determine this, the quantity "t" was invoked. The "t" values are shown in Table XXIV (Section c). The next section (d) shows the probability of finding the "t" values presented in the preceding section. An example of the procedure used to compute the mean differences, and "t" values is given in Appendix 5.

Of the 40 "t" quantities only 4 were significant at the 5% level. Two of these were significant at the 1% level. As indicated in Section c of Table XXIV the significant values were found in the small shipments as well as the large shipments. All of the mean differences except 4 could differ from zero just as a result of chance.

Although 4 significant values are slightly larger than would be expected from a normal population, the hypothesis that in the long run (one year) it makes no difference whether the producer is paid on the basis of a one case sample or the grade of the entire shipment must be accepted. Therefore, the use of a one case sample was not biased in overpaying or underpaying these producers over a one year period.

TABLE XXIII

Forty Selected Producers Grouped According to Plants, Color of Eggs, and Arrayed According to the Average Size of the Weekly Shipments During the Year

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(dozen)	(dozen)	(dozen)	(dozen)
50.1	48.8	51.4	45.1
54.9	63.7	58.4	45.3
55.9	74.5	62.5	49.6
56.4	75.3	63.2	58.2
62.0	75.4	67.1	82.3
63.2	112.7	86.0	200.9
76.4	125.4	86.5	
89.0	140.5	92.1	
129.7	146.0	145.9	
142.3	168.0	227.1	
270.6	169.0		
309.8			
322.1			

TABLE XXIV

Statistical Analysis of the Differences between the Values per Case Based on the Grade of a One Case Sample and the Value per Case Based on the Grade of the Total Shipment each Week during the Year for 40 Selected Producers

(Section a - Mean Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(cents)	(cents)	:	(cents)	(cents)
.45	1.65	:	-25.86	- .45
- 5.56	4.04	:	1.51	- .52
- 9.73	5.93	:	- 8.14	- 9.58
- .64	- 1.89	:	5.74	- .31
4.95	4.14	:	- 6.86	3.81
4.53	5.21	:	3.81	- 1.61
7.95	3.69	:	10.51	
12.06	7.22	:	2.18	
- 1.62	- 1.84	:	- .61	
- 1.11	- 2.36	:	- 9.28	
5.64	16.57	:		
- 1.66		:		
- .88		:		

(Section b - The Standard Deviations of the Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(cents)	(cents)	:	(cents)	(cents)
26.655	37.120	:	47.192	13.129
25.248	21.327	:	12.589	17.519
38.187	26.912	:	27.402	33.007
38.358	19.953	:	36.418	48.009
15.567	39.318	:	27.591	14.560
24.931	29.205	:	14.473	15.564
73.740	28.426	:	24.497	
42.605	39.636	:	40.194	
33.608	26.717	:	44.435	
70.914	52.856	:	19.997	
27.843	56.829	:		
36.267		:		
36.465				

TABLE XXIV (Continued)

(Section c - "t" Values of the Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
.090	.282	:	-3.288*	- .153
-1.411	1.286	:	.731	- .149
-1.463	1.426	:	-1.657	-1.422
- .105	- .585	:	1.021	- .035
1.959	.707	:	-1.315	1.333
1.255	1.287	:	1.804	- .636
.716	.871	:	2.813*	
1.698	1.300	:	.318	
- .300	- .498	:	- .082	
- .096	- .287	:	-2.626	
1.215	2.041*	:		
- .290		:		
- .157		:		

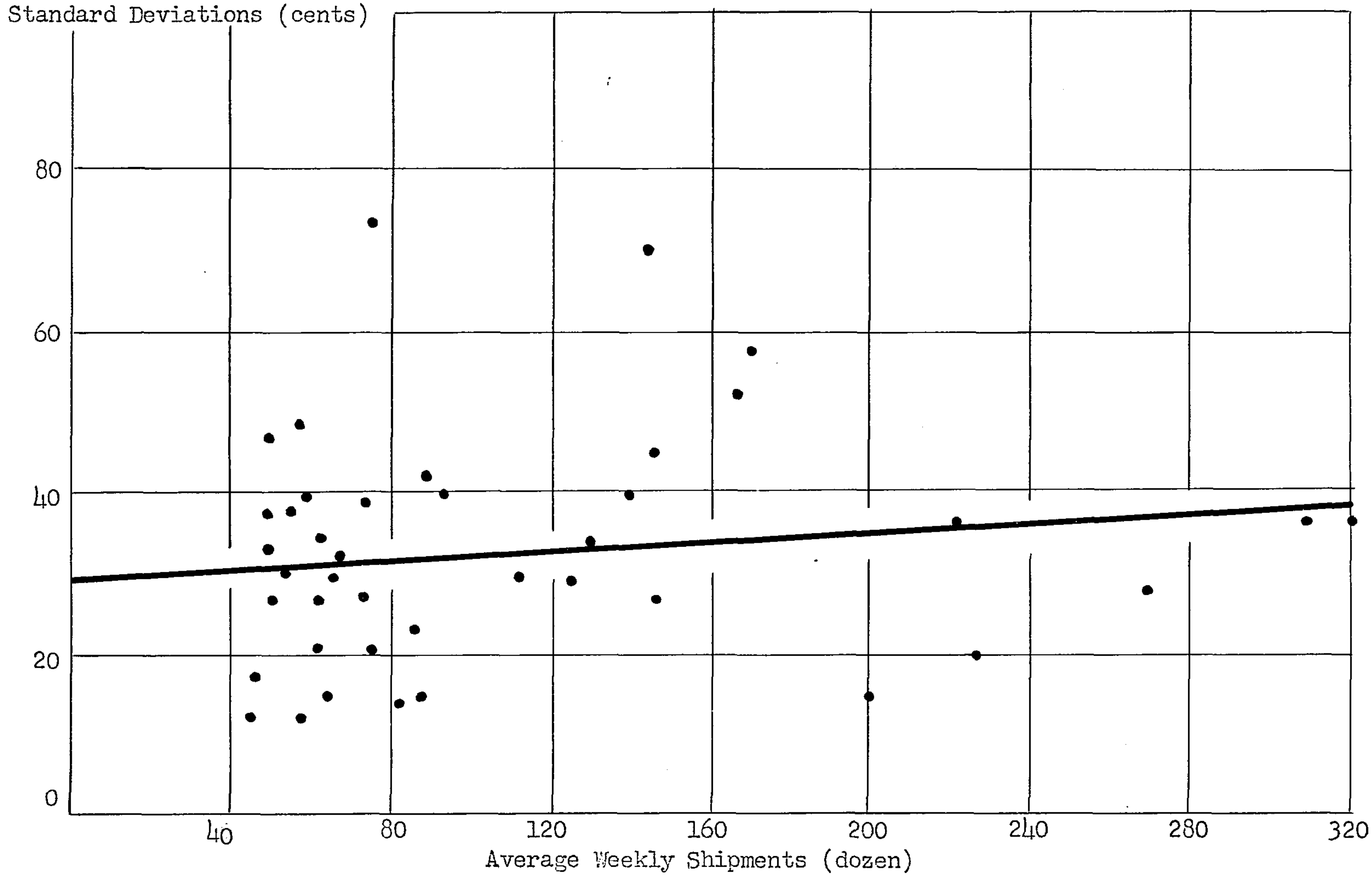
* significant at the 5% level

(Section d - The Probabilities of the above "t" Values)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	PlantII
(%)	(%)	:	(%)	(%)
50	50	:	<01	50
10	20	:	40	50
10	10	:	10	10
50	50	:	30	50
05	40	:	10	10
20	20	:	05	40
40	30	:	01	
10	20	:	50	
50	50	:	50	
50	50	:	<01	
20	02	:		
50		:		
50		:		

< = less than

CHART I Regression of the Standard Deviation on the Average Weekly Shipment, Using a One Case Sample Each Week



Even though this sampling method was not biased over the period of a year, there were random errors when the sampling method was applied to an individual weekly shipment. The producer may be either overpaid or underpaid on each shipment when a sampling method is used. In selecting or using a sampling procedure, the size of the overpayment or underpayment on a single shipment must be taken into consideration. A sampling method could be unbiased in the long run, but the random error might be so large on individual shipments that the method would not be acceptable.

An index of the variation between the values for a single shipment is the Standard Deviation. The Standard Deviations computed for the 40 producers are shown in Table XXIV (Section b). For example, the standard deviation for the first producer in column 1 (of section b) is 26.6¢. This indicates that two-thirds of the overpayments or underpayments on single shipments were 26.6¢ or less per case. One-third of the time the overpayment or underpayment was larger than 26.6¢ per case when this sampling procedure was used. The standard deviations ranged from 12.5¢ to 73.7¢, with an average of 35.5¢ per case for these 40 producers.

In the sampling procedure tested, a 30 dozen sample was taken from each shipment regardless of the size of the shipment. The average weekly shipments of these producers varied from 45.1 to 322.1 dozen per week. Since a 30 dozen sample taken from a shipment of 45 or 50 dozen would be a much larger per cent of the total shipment than a 30 dozen sample taken from a shipment of 300 dozen, it might seem logical that the variation between the value per case based on the one case sample and the value based on the entire shipment would increase as the weekly shipments became larger. Chart I shows the relationship between the standard deviations and the size of the average weekly shipment of the 40 producers. The regression line shows there is only a slight increase in the size of standard deviation as the size of the shipment increased, but the correlation coefficient between the size of shipment and the standard deviation was very small (.13009). This indicates that there was very little relationship between the size of the weekly shipment and the standard deviation of the differences. In using "t" to test the coefficient of correlation, the standard deviations of the differences was found to be independent of the size of the average weekly shipment. The "t" value (.8085) was not significant. The method used in computing the regression line, correlation coefficient and "t" test is shown in appendixes 6, 7, and 8.

BASING PAYMENTS TO PRODUCERS FOR THREE TO FIVE WEEKS ON ONE 30 DOZEN SAMPLE

In this sampling procedure for determining producer payments, the grade of a one case sample was used to determine, not only the value of the total shipment from which the sample was taken, but also to determine the value ofthe two following three and four weekly shipments of the same producer. In investigating this procedure, the value per case based on the grade of the one case sample was compared with the average value per case based on the grade of the entire shipment from which the sample was taken and also the value per case based on the grade of the entire shipment of the following 2, 3, or 4 weeks.

The value per case based on the grade of the one case sample and the average value per case based on the grade of the entire shipments of the 40 producers analysed in the previous section were used to investigate the accuracy of this method of payment. The method of selecting the sample, computing the values per case, and other qualifications were all described in the previous section. Since most of the records of the 52 shipments by each producer was started on one of two dates (October 25 or March 15), the first shipment used as a sample was selected at random among the first three, four or five shipments of each producer. This was done in order to distribute the samples over each week of the one year period. The number of shipments was dependent on the number of weeks the sample was to be used as a basis of payment. For the individual producer, the one case sample was computed every third, fourth or fifth week. For example, in the record of the shipments in appendix 4, the one case sample of the third shipment was randomly selected as the first sample to be compared with the values based on the entire grade of this shipment and the entire grade of the next two shipments. After selecting the first sample, the rest of the samples were automatically determined for the year. In this example, the next one case sample would be from the sixth shipment. The differences between the value based on the sample and the average values based on the actual grading of the entire shipments were computed and the same statistical analysis was applied as was used in the previous section. The mean differences, "t" values, probabilities, and standard deviations are all arranged in the same order as Table XXIII.

<u>One Case Sample As Basis Of Payment For Three Weeks</u> (Method B) The value of a one case sample was compared with the average value per case based on the grade of the entire shipment from which the sample was taken and the average value per case based on the entire grade of the following two shipments. The mean differences between these values is shown in Table XXV (Section a). Seventeen of the values were negative and twenty-three were positive. If this sampling procedure had been used as a basis of payment, 17 of the producers would have been overpaid and twenty-three would have been underpaid. The "t" test was used to test the hypothesis that "these differences do not differ significantly from zero." Section c of Table XV shows the "t" values and Section d shows the probability of finding the computed "t" values in the preceding section. Only 3 of the 40 values were significant at the 5% level. Although this is about the number expected, all three were also significant at the

1% level. The seven significant "t" values in the 5 to 10% probability classification was larger than expected from a normal population.

The standard deviations in the value per case with this sampling procedure is shown in Table XXV (Section b). The range was from 25¢ to $1.12 per case. The mean of the standard deviations was 52.77¢. Chart II shows the relationship between the size of the standard deviation and the size of the weekly shipment. There was a slight increase in the size of standard deviations with the increase in the size of the weekly shipments, but the coefficient of correlation was very small (.06621). The "t" test showed the size of the standard deviations were independent of the size of the average weekly shipments.

TABLE XXV

Statistical Analysis of the Differences between the Value per Case Based on the Grade of a One Case Sample of Eggs Every Third Week and the Value per Case Based on the Grade of the Total Shipment each Week for each of the Three week Periods during the Year for 40 Producers

(Section a - Mean Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(cents)	(cents)	:	(cents)	(cents)
11.25	.30	:	- 1.98	- 9.67
-11.62	- 3.93	:	6.23	- 9.37
-20.00	12.79	:	19.34	- 3.93
20.98	- 2.22	:	28.60	- 9.71
3.19	- 2.19	:	- 3.34	1.80
- 5.82	6.96	:	11.29	4.62
28.04	4.59	:	10.83	
11.45	1.26	:	14.25	
5.31	-15.12	:	- 1.53	
-14.02	11.04	:	-10.08	
5.41	17.49	:		
9.12		:		
- 5.35				

(Section b - Standard Deviations of the Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(cents)	(cents)	:	(cents)	(cents)
40.831	36.775	:	67.450	25.087
53.014	33.990	:	34.316	28.094
59.395	44.508	:	81.910	41.523
46.002	65.567	:	63.639	48.694
34.709	29.710	:	49.346	23.797
37.846	51.998	:	28.615	41.666
111.745	41.179	:	40.831	
67.720	19.910	:	50.483	
77.285	56.587	:	37.904	
77.755	71.800	:	34.670	
44.604	71.126	:		
54.104		:		
49.484		:		

TABLE XXV (Continued)

(Section c - "t" Values of the Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
1.6544	.0521	:	- .1949	-1.8924
-1.4709	- .7676	:	1.1494	-1.6348
-2.0222	1.8644	:	1.4563	- .5192
2.9886*	- .2167	:	3.0148*	-1.1657
.6029	- .4845	:	- .4010	.4167
- .8981	.9469	:	2.9554*	.6927
1.7223	.7819	:	1.8418	
1.0957	.5164	:	1.6964	
.4611	-1.9310	:	- .2492	
-1.1683	1.0434	:	-1.7439	
.7213	1.6882	:		
1.0806		:		
- .7086		:		

Significant at the 5% level

(Section d - Probabilities of the above "t" Values)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(%)	(%)	:	(%)	(%)
10	50	:	50	05
10	40	:	20	10
05	05	:	10	50
< 01	50	:	< 01	20
50	50	:	50	50
30	30	:	< 01	40
05	40	:	05	
20	50	:	10	
50	05	:	50	
20	30	:	05	
40	10	:		
10		:		
40		:		

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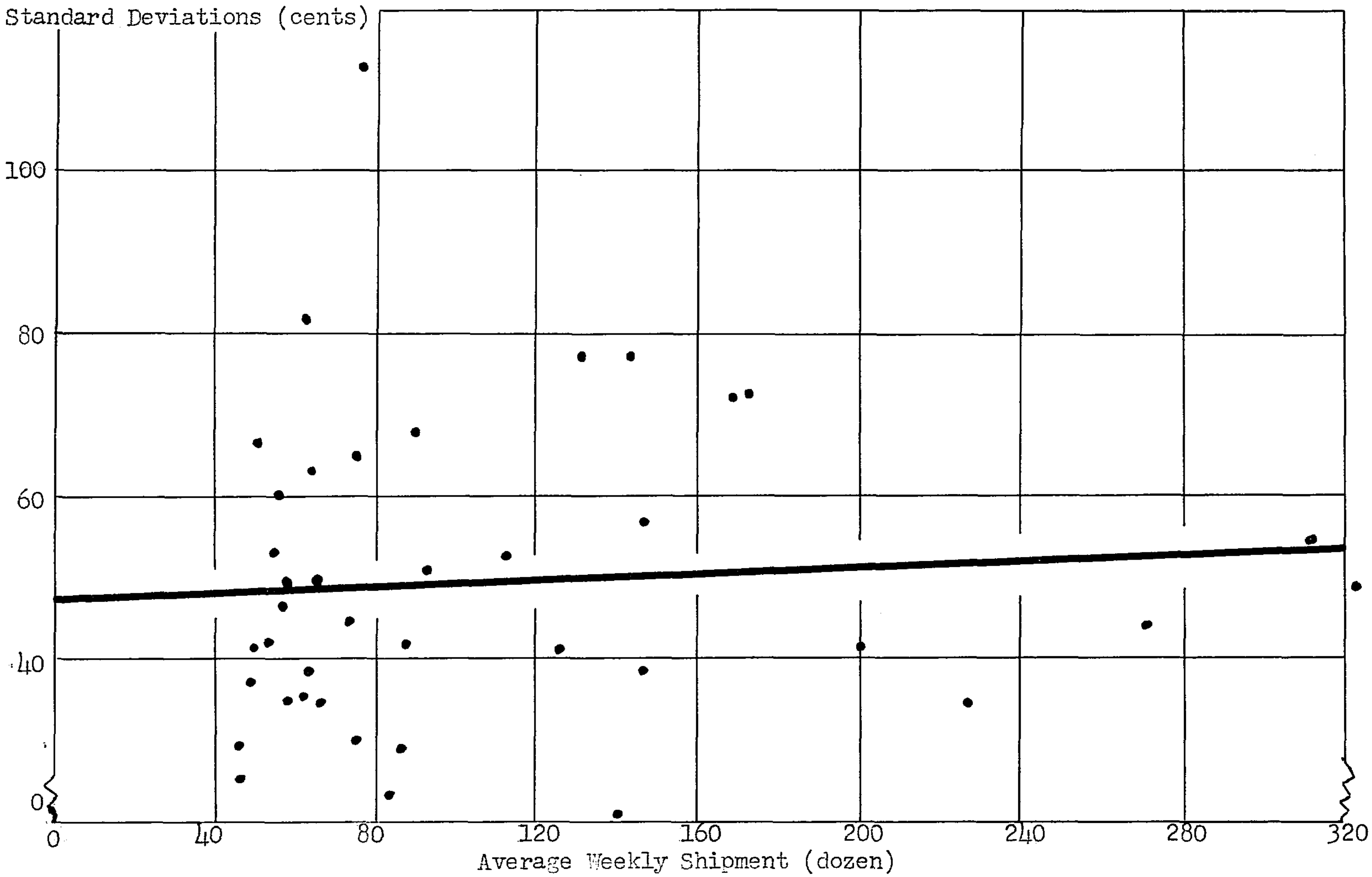
CHART II Regression of the Standard Deviation on the Average Weekly Shipment, Using a One Case Sample Every Third Week



One Case Sample As A Basis of Payment For Four Weeks (Method C) This procedure involved comparing the value of a one case sample with the average value per case based on the grade of the total shipment from which the sample was taken and the average value per case based on the grade of the total shipment for each of the following three shipments. The first shipment from which the one case sample was taken was selected at random among the first four shipments of each producer.

The mean differences between the actual value per case and the value per case based on this sampling procedure is shown in Table XXVI (Section a). Nineteen of the mean differences were negative and twenty-one were positive. The "t" quantities and probabilities are shown in sections c and d. Six of the "t" values were significant at the 5% level with three of them negative and three positive. Less than three significant values are normally expected from a population of this size. Only one "t" value was significant at the 1% level.

The standard deviations of the differences in this sampling procedure are shown in Section b. The mean of these values was 54.5¢. The relationship between size of the average weekly shipment and the amount of the standard deviation is shown in Chart III. Here again, as with the previous sampling procedures there was a slight increase in the size of the standard deviation as the size of the shipments increased, but the correlation coefficient was very small (.1121). The "t" test showed the standard deviations were independent of the size of the average weekly shipments tested.

TABLE XXVI

Statistical Analysis of the Differences between the Value per Case Based on the Grade of a One Case Sample of Eggs every Fourth Week and the Value per Case Based on the Grade of the Total Shipment each Week for each of the Four Week Periods during the Year for 40 Producers

(Section a - Mean Differences)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(cents)	(cents)	(cents)	(cents)
18.06	- 6.88	- 6.87	-12.33
- 9.89	3.88	- 1.81	- 2.78
7.00	15.00	7.88	- 7.75
30.23	- 6.45	5.63	- 8.11
4.36	8.37	-21.31	.36
- 2.85	- 8.25	8.11	8.25
16.07	-11.52	5.58	
5.44	2.72	22.35	
29.94	-23.28	-12.31	
-13.25	7.00	- .08	
- .80	12.92		
- 7.68			
16.55			

(Section b - Standard Deviations of the Differences)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(cents)	(cents)	(cents)	(cents)
53.233	45.796	71.791	35.442
63.085	37.984	37.641	34.204
67.623	55.638	78.558	43.386
44.548	69.540	55.784	45.743
29.057	35.413	46.311	35.462
40.591	52.261	37.481	68.262
88.942	37.095	37.649	
58.971	53.119	51.883	
81.198	70.267	55.367	
50.764	66.223	51.563	
39.810	76.409		
50.838			
67.767			

TABLE XXVI (Continued)

(Section c - "t" Values of the Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
2.0352	- .9733	:	- .6423	-1.8082
-1.0766	.7167	:	- .3120	- .4605
.6548	1.5481	:	.6346	-1.0117
4.4757*	- .6019	:	.6476	-1.0811
.9601	1.5503	:	-2.7228*	.0610
- .4270	-1.1293	:	1.4517	1.2086
1.2253	-2.1517*	:	1.0282	
.5764	.3632	:	2.5483*	
2.5544*	-2.2710*	:	-1.3882	
-1.7314	.7254	:	- .0093	
- .1274	1.1841	:		
-1.0054		:		
1.6746		:		

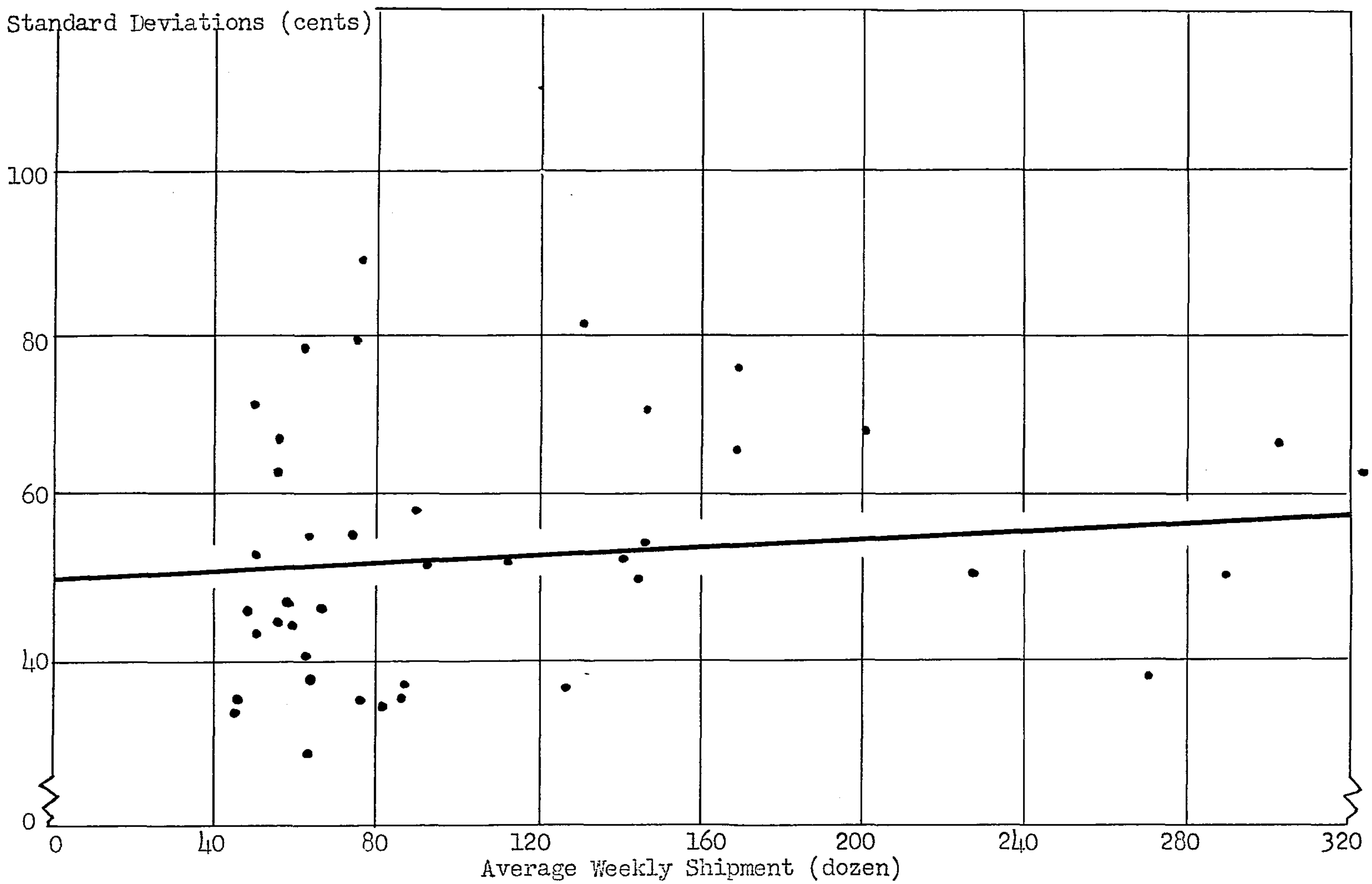
*Significant at the 5% level

(Section d - Probabilities of the above "t" Values)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(%)	(%)	:	(%)	(%)
05	30	:	50	05
20	40	:	50	50
50	10	:	50	30
<01	50	:	50	20
30	10	:	01	50
50	20	:	10	50
20	02	:	30	
50	50	:	01	
01	02	:	10	
05	40	:	50	
50	20	:		
30		:		
10		:		

< Less Than

CHART III Regression of the Standard Deviation on the Average Weekly Shipment, Using a One Case Sample Every Fourth Week



<u>One Case Sample As Basis of Payment For Five Weeks</u> (Method D) The value of a one case sample was compared with the average value per case based on the grade of the total shipment from which the sample was taken and the average value per case based on the total grade of each of the following four shipments. With this sampling procedure, a one case sample was taken every fifth week. The first shipment from which the one case sample was taken was selected at random among the first five shipments of each producer.

Here again, the same testing procedure was followed as in analysing the preceding sampling methods. The mean differences, "t" values, and probabilities are shown in Table XXVII. There were nine significant "t" values at the 5% level and they were found in both the large and small shipments. These were considerably more significant values than would normally be expected from 40 "t" values computed from a normally distributed population. Four of these "t" values were so large that there was less than one chance in a hundred of any of them coming from a normally distributed population.

The standard deviations of the differences are listed in Table XXVII (Section b). The mean of the standard deviations was 58.26¢ per case, which was slightly higher than either of the previous sampling procedures. The regression line of the standard deviations on the size of weekly shipment increased slightly with the size of the shipment, but the correlation coefficient (r) between these values was very small (.0764). The "t" test, as with previous sampling procedures, indicated the size of the standard deviations were independent of the size of the shipments.

TABLE XXVII

Statistical Analysis of the Differences between the Value per Case Based on the Grade of a One Case Sample of Eggs Every Fifth Week and the Value per Case Based on the Grade of the Total Shipment each Week for each of the Five Week Periods during the Year for 40 Producers

(Section a - Mean Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(cents)	(cents)	:	(cents)	(cents)
12.69	- 7.89	:	-14.81	-14.18
- 2.85	10.86	:	6.27	10.93
-34.97	22.86	:	-32.49	-31.73
12.10	-14.61	:	-10.58	- 4.56
13.95	- 2.70	:	8.74	12.03
- 2.11	- 2.57	:	.25	19.43
8.48	5.39	:	9.49	
1.00	- 6.65	:	23.95	
- 7.71	-12.61	:	21.57	
-33.72	- 8.06	:	6.51	
12.90	19.57	:		
11.28		:		
14.34		:		

(Section b - Standard Deviations of the Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(cents)	(cents)	:	(cents)	(cents)
66.591	49.411	:	55.266	27.090
56.409	54.947	:	42.864	32.406
55.871	60.321	:	67.752	38.867
74.686	70.246	:	84.439	48.664
40.337	39.994	:	52.747	23.679
50.585	47.580	:	52.524	61.619
80.170	34.109	:	44.346	
54.951	49.090	:	56.615	
80.903	69.137	:	79.141	
89.462	63.628	:	53.297	
58.120	84.180	:		
37.032		:		
48.396		:		

TABLE XXVII (Continued)

(Section c - "t" Values of the Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
1.1070	-1.0601	:	-1.7366	-2.7694*
- .3506	1.3831	:	.9822	1.8480
-3.4279*	2.4557*	:	-3.0704	-4.4720*
1.1228	-1.3317	:	- .8408	.5624
2.2940*	- .4493	:	.9663	3.0332*
- .2504	- .3845	:	.0332	1.9938
.7262	1.1057	:	1.4880	
.1168	- .9387	:	2.6417*	
- .6394	-1.2770	:	1.8078	
-2.3537	- .8689	:	.7538	
1.4038	1.6275	:		
2.0449		:		
1.9656		:		

* Significant at 5% level

(Section d - Probabilities of the above "t" Values)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(%)	(%)	:	(%)	(%)
20	20	:	05	01
50	10	:	30	05
<01	02	:	<01	<01
20	10	:	40	50
02	50	:	30	<01
50	50	:	50	05
40	20	:	10	
50	30	:	01	
50	20	:	05	
02	30	:	40	
10	10	:		
05		:		
05		:		

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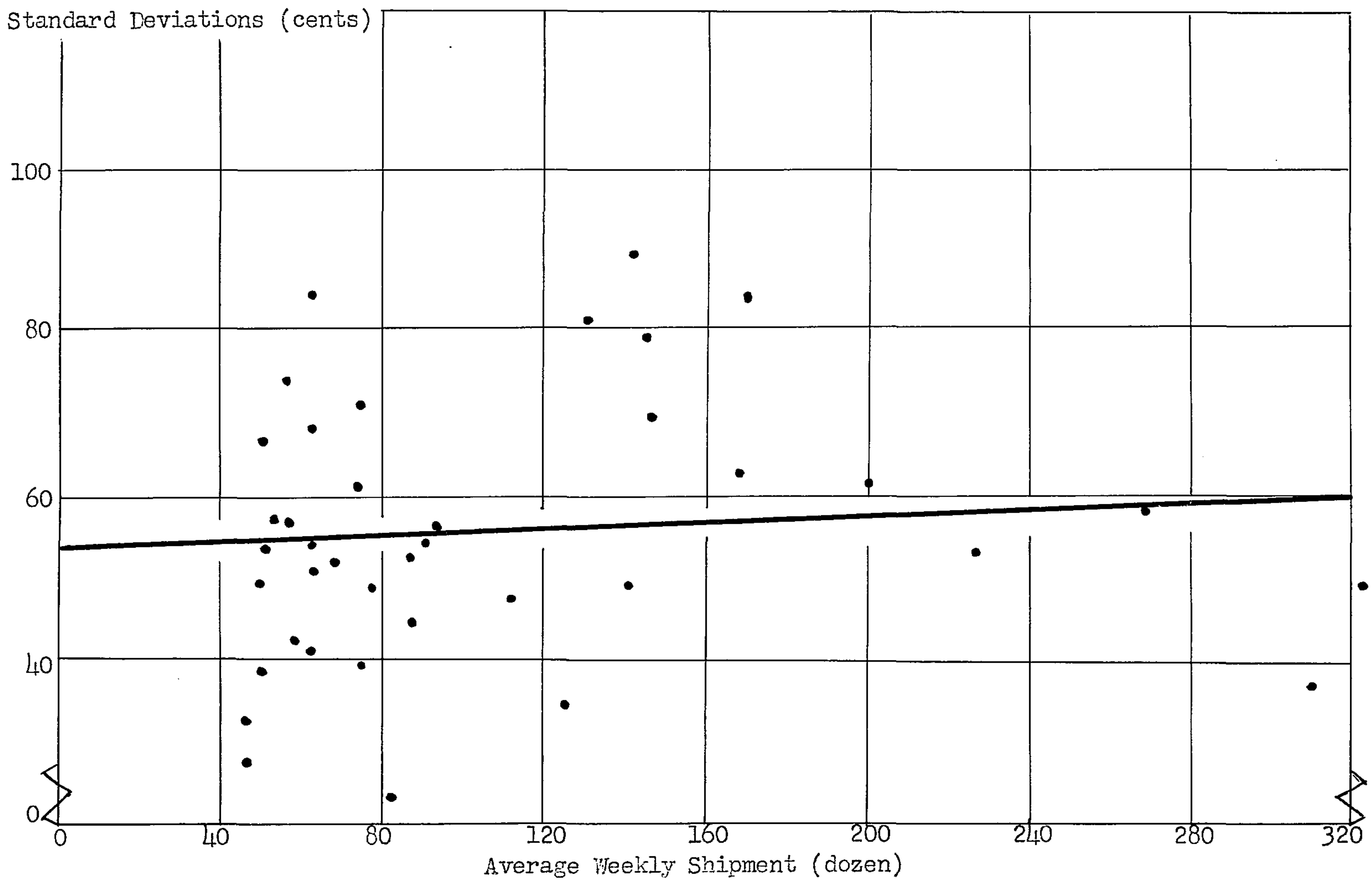
CHART IV Regression of the Standard Deviation on the Average Weekly Shipment, Using a One Case Sample Every Fifth Week



BASING PAYMENTS TO PRODUCERS ON THE GRADE OF ONE ENTIRE SHIPMENT

In this sampling method the total grade of one shipment was used as the basis of payment for a number of following shipments. In this phase of the project the average value per case based on the grade of the entire shipment for one week was compared with the average values per case based on the grade of the entire shipments of each of the following two, three or four weeks.

In testing this method, the weekly shipments of the same forty producers were used plus the weekly shipment of twelve other producers. Nine of these twelve additional producers were too small (less than 45 dozen) to select a 30 dozen sample each week. The average weekly shipment of the other three were large enough, but the candlers failed to grade a one case sample so many times that the shipments of the three producers could not be considered in the tests using the one case sample. The records of these twelve additional producers were used in testing this sampling method since only the grade of the total shipment was required. The average weekly shipments of the 52 producers used in this phase of the project are shown in Table XXXIII. The mean differences, "t" value, probabilities, and standard deviations of the differences are arranged in the same order as Table XXXIII. The statistical comparisons were computed the same way as in the previous sections except that the total grade of one shipment was used as the sample instead of a one case sample. The statistical analysis and the qualifications are the same. The first shipment used as a sample was selected at random among the first three, four or five shipments.

TABLE XXVIII

The Size of the Average Weekly Shipment of Eggs Marketed by 52 Selected Producers during One Year, Grouped by Plant and Color of Eggs

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(dozen)	(dozen)	:	(dozen)	(dozen)
24.5	27.0	:	21.9	37.0
36.8	42.1	:	34.4	40.0
50.1	48.8	:	41.2	45.1
54.9	63.7	:	51.4	45.3
55.9	74.5	:	58.4	49.6
56.4	75.3	:	62.5	58.2
62.0	75.4	:	63.2	82.3
63.2	112.7	:	64.6	200.9
76.4	125.4	:	67.1	
89.0	140.5	:	86.0	
129.7	146.0	:	86.5	
142.3	168.0	:	92.1	
151.8	169.0	:	145.9	
178.8		:	227.1	
270.6		:		
309.8		:		
322.1		:		

Entire Shipment Every Third Week As A Basis Of Payment For The Following Two Weeks (Method E) With this sampling procedure the grade of one entire shipment was used as a basis of payment for that shipment and the shipments the following two weeks. The following table shows the mean differences, "t" values, and probabilities computed from the differences in values computed by the methods described above for 52 producers. Twenty-eight of the mean differences and "t" values were negative and twenty-two were positive.

The "t" test was used to test the hypothesis that the mean differences do not differ significantly from zero. Four of the "t" values were significant at the 5% level. Only one of these values was significant at the 1% level. Section b shows the standard deviations computed with for this sampling procedure. The range was from 21.57¢ to $1.31 per case and the mean was 61.52¢ per case. Chart V shows the relationship between the standard deviation and the size of the average weekly shipment. The size of the standard deviation decreased with the size of the shipment. In all of the previous sampling procedures the standard deviation increased with the size of the shipment. The coefficient of correlation between the standard deviations and the weekly shipments was -.3736. The "t" test showed that the standard deviations were independent of the size of the weekly shipment (not significant at the 5% level).

TABLE XXIX

Statistical Analysis of the Differences between the Value per Case Based on the Grade of Every Third Shipment and the Value per Case of the Following Two Shipments of 52 Producers for one Year

(Section a - Mean Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(cents)	(cents)	:	(cents)	(cents)
15.79	11.60	:	1.00	- 6.33
- 2.03	4.74	:	5.88	- 8.79
3.41	- 1.62	:	12.33	3.81
8.42	- 5.47	:	- 4.12	5.21
- 2.82	10.70	:	- 6.42	- .13
- 9146	11.13	:	-39.45	- 6.13
- 5.03	- 6.58	:	21.00	- 9.00
13.94	-17.09	:	2.48	- 1.58
7.79	-14.56	:	-26.00	
- 2.94	-11.24	:	6.94	
- 9.18	.21	:	8.56	
-21.62	8.16	:	7.75	
- 7.25	-25.35	:	4.67	
-11.55		:	-11.82	
-10.75		:		
7.53		:		
8.16		:		

(Section b - Standard Deviations of the Differences)

White Egg Shipments		:	Brown Egg Shipments	
Plant I	Plant II	:	Plant I	Plant II
(cents)	(cents)	:	(cents)	(cents)
103.100	69.244	:	72.176	65.945
74.898	54.104	:	93.104	93.520
61.895	57.724	:	130.622	38.061
74.521	42.167	:	58.767	35.504
76.142	53.059	:	39.033	37.632
63.278	42.914	:	62.259	52.126
50.208	48.247	:	49.980	21.566
70.009	50.660	:	73.752	85.868
47.464	43.656	:	82.214	
40.664	54.247	:	30.689	
79.594	26.178	:	36.282	
47.815	31.797	:	67.129	
64.521	73.604	:	33.705	
60.971		:	44.992	
42.453		:		
54.300		:		
45.743		:		

TABLE XXIX (Continued)

(Section c - "t" Values of the Differences)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
.8734	.9177	.0783	- .5257
- .1303	.5113	.3222	- .5399
.3114	- .1633	.4906	.5378
.6492	- .7342	.4913	.8430
- .2161	1.1593	- .9571	- .0193
- .8463	1.4700	-3.4156*	- .6649
- .5762	- .7352	2.3783*	-2.2113*
1.1520	-1.9443	.1931	- .1057
.9442	1.9465	-1.7615	
- .4224	-1.1907	1.3219	
-2.0349	.0470	1.3762	
-2.4347*	1.4571	.6107	
- .6360	-1.9190	.7969	
-1.0548		-1.5096	
-1.4333			
.7852			
.9336			

* significant at the 5% level

(Section d - Probabilities of the above "t" Values)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(%)	(%)	(%)	(%)
30	30	50	50
50	50	50	50
50	50	50	50
50	40	50	40
50	20	30	50
40	10	<01	50
50	40	02	02
30	05	50	50
30	05	05	
50	20	10	
05	50	10	
02	10	50	
50	05	40	
30		10	
10			
40			
30			

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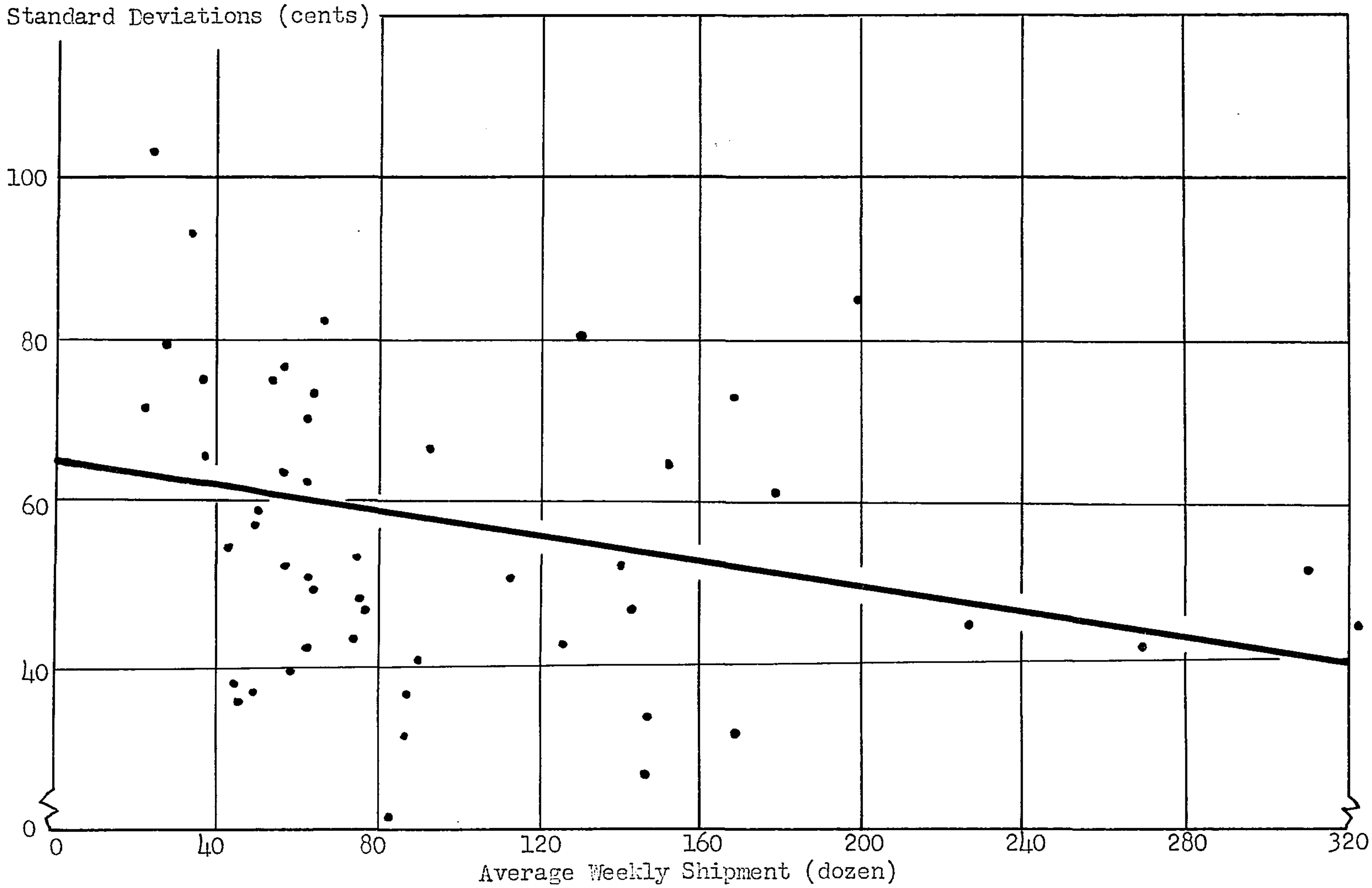
CHART V Regression of the Standard Deviation on the Average weekly Shipment, Using the Total Shipment Every Third Week



<u>Entire Shipment Every Fourth Week As a Basis of Payment For the Following Three Weeks</u> (Method F) With this sampling procedure the grade of one entire shipment of eggs was used as a basis of payment for that shipment and the following three weekly shipments.

The following table shows the results of the comparisons made between the actual values per case and the average value per case based on the grade of every fourth entire shipment.

There were almost as many negative as positive mean differences and "t" values, but there were considerable more significant "t" values than would be expected from a group of data of this size. There were 11 significant values at the 5% level. These significant values were found among the small as well as the large producers.

Section b of Table XXX shows the standard deviations computed for each of these groups of differences. The average mean difference with this sampling procedure was 61.70¢ per case. The regression line again shows a negative slope. The size of the standard deviation decreased with an increase in the size of the average weekly shipment. The correlation coefficient was only -.2284 and the "t" test indicated that the size of the standard deviation was independent of the size of the average weekly shipment.

TABLE XXX

Statistical Analysis of the Differences between the Value per Case Based on the Grade of Every Fourth Shipment and the Value per Case of the Following Three Shipments of 52 Producers for One Year

(Section a - Mean Differences)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(cents)	(cents)	(cents)	(cents)
-43.11	-22.03	27.54	- 8.34
2.87	12.53	20.53	29.53
10.06	- 2.19	-13.84	- 7.28
-21.40	-14.16	.27	1.69
18.34	16.94	- 7.11	5.94
2.56	19.97	20.53	10.14
-18.43	- 7.64	- 5.33	- 3.15
-15.00	- 9.68	7.97	2.54
3.35	1.84	- 8.57	
- 5.00	-30.56	4.77	
- 3.07	7.44	8.77	
3.25	2.29	3.43	
-22.86	11.59	- 5.11	
10.74		5.92	
1.97			
17.00			
-20.85			

(Section b - Standard Deviations of the Differences)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(cents)	(cents)	(cents)	(cents)
99.840	63.506	61.161	87.606
70.552	54.069	97.681	48.362
53.882	43.773	116.409	34.183
51.724	46.987	85.335	38.545
65.177	46.495	56.645	47.008
67.150	47.178	79.781	45.495
41.976	56.696	85.587	25.366
68.396	49.612	79.279	110.133
66.143	37.095	76.970	
66.100	49.039	42.597	
61.403	45.629	38.487	
37.603	31.493	30.856	
62.614	64.983	28.956	
57.252		63.641	
43.998			
48.552			
48.127			

TABLE XXX (Continued)

(Section c - "t" Values of the Differences)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
-2.626*	-2.063	2.664*	- .5637
.2506	1.428	1.151	3.663 *
1.120	- .3049	- .6730	-1.277
-2.433 *	-1.833	.0192	.2747
1.735	2.186	- .7732	.7485
.2319	2.575 *	1.455	1.337
-2.572 *	- .8083	- .3740	- .7163
-1.352	1.211	.6035	.1403
.3077	.2889	- .6773	
- .4329	3.792 *	.6795	
- .3054	1.0173	1.423	
.4887	.4304	.6098	
-2.190 *	1.040	-1.0530	
1.110		.5818	
.2703			
2.031			
-2.564 *			

* significant at the 5% level

(Section d - Probabilities of the above "t" Values)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(%)	(%)	(%)	(%)
01	02	01	50
50	10	20	< 01
20	50	50	20
02	05	50	50
05	02	40	40
50	01	10	10
01	40	50	40
10	20	50	50
50	50	50	
50	< 01	50	
50	30	10	
50	50	50	
02	30	30	
20		50	
50			
05			
01			

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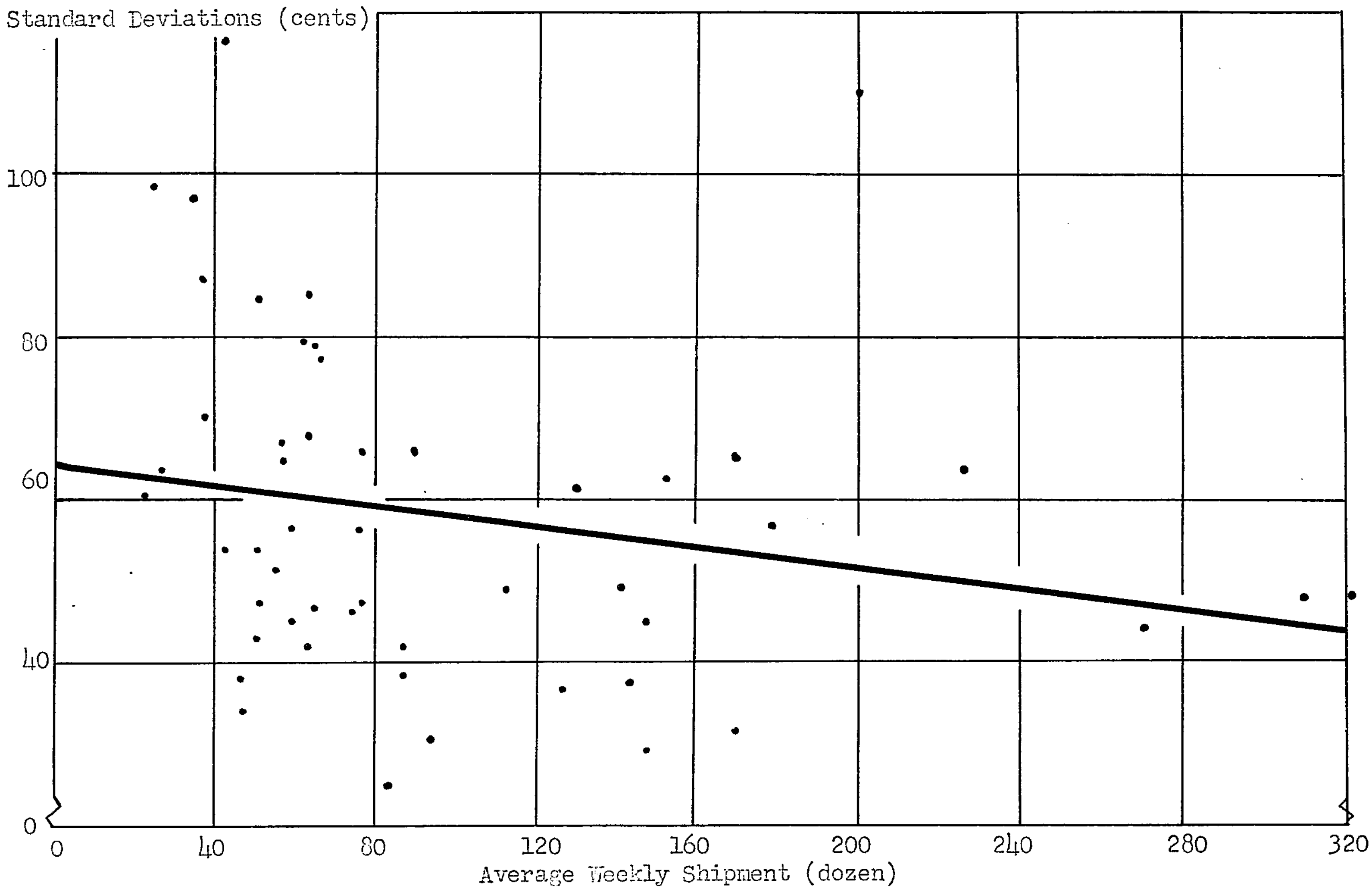
CHART VI Regression of the Standard Deviation on the Average Weekly Shipment, Using the Total Shipment Every Fourth Week



Entire Shipment Every Fifth Week As a Basis for Payment For the Following Four Weeks (Method G) In this sampling procedure the total grade of a single shipment was used as a basis of payment for that shipment and the next four shipments, or a total of five shipments.

The following table (XXXI) shows the results of the comparisons made between the actual and the average value per case based on the grade of every fifth shipment. There were seven significant values at the 5% level with this sampling method. Five of these seven values were positive and two were negative. Table XXXI (Section b) shows the standard deviations of these differences which averaged 70.01¢ per case. The regression line (Chart XI) shows a negative lope, as did the previous two methods. The size of the standard deviation decreased as the size of the average weekly shipment increased. The coefficient of correlation between the standard deviations and average weekly shipment was -.1875. The "t" value computed was not significant at the 5% level, which indicated that the size of the standard deviation was independent of the size of the shipment.

TABLE XXXI

Statistical Analysis of the Differences between the Value per Case Based on the Grade of Every Fifth Shipment and the Value per Case of the Following Four Shipments of 52 Producers for One Year

(Section a - Mean Differences)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(cents)	(cents)	(cents)	(cents)
-15.56	-20.62	- 9.00	-22.17
- 3.26	7.28	47.06	-12.97
21.31	2.98	- 7.66	- 3.24
19.38	11.60	-12.67	.38
-24.18	- 3.69	-11.08	.49
22.00	-10.21	15.32	25.66
26.33	-13.73	- 8.42	1.26
- 5.50	-12.97	17.95	25.58
2.90	5.40	1.48	
-20.76	-14.78	2.32	
-13.68	1.69	- 5.23	
4.67	5.82	6.21	
8.46	4.45	5.85	
30.70		5.25	
- 4.63			
10.55			
-14.47			

(Section b - Standard Deviations of the Differences)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(cents)	(cents)	(cents)	(cents)
100.870	67.397	68.898	93.971
54.684	50.291	88.489	114.147
71.064	49.345	44.541	33.969
49.608	36.080	74.333	29.581
69.625	64.363	62.198	48.317
100.854	75.200	74.306	90.919
53.943	68.493	90.398	25.871
82.898	71.263	74.554	50.067
71.777	31.580	111.095	
63.285	72.681	49.229	
87.101	54.059	43.357	
51.049	46.581	46.951	
58.695	50.450	61.235	
79.865		58.582	
78.349			
58.830			
44.121			

TABLE XXXI (Continued)

(Section c - "t" Values of the Differences)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
- .9637	-1.8619	- .7847	-1.4153
.3687	.9043	3.0550*	- .7098
1.872	.3864	- .3217	- .5086
2.470 *	2.0334*	-1.0784	.1498
-2.1688*	- .3588	-1.1115	.0596
1.3623	- .8376	1.1123	1.7396
3.0486*	-1.2674	- .5744	.2883
- .4189	-1.1233	1.5035	3.185 *
.2591	1.0678	.0840	
-1.8842	-1.2857	.2982	
-1.0061	.1954	- .7622	
.5303	.7652	.7719	
.9011	.5450	.6056	
2.3384		.5676	
- .3647			
1.0943			
-1.9680			

* significant at the 5% level

(Section d - Probabilities of the above "t" Values)

White Egg Shipments		Brown Egg Shipments	
Plant I	Plant II	Plant I	Plant II
(%)	(%)	(%)	(%)
30	05	40	10
50	30	<01	40
05	50	50	50
02	02	20	50
02	50	20	50
10	40	20	05
<01	20	50	50
50	20	10	<01
50	20	50	
05	20	50	
30	50	40	
50	40	40	
30	50	50	
02		50	
50			
20			
05			

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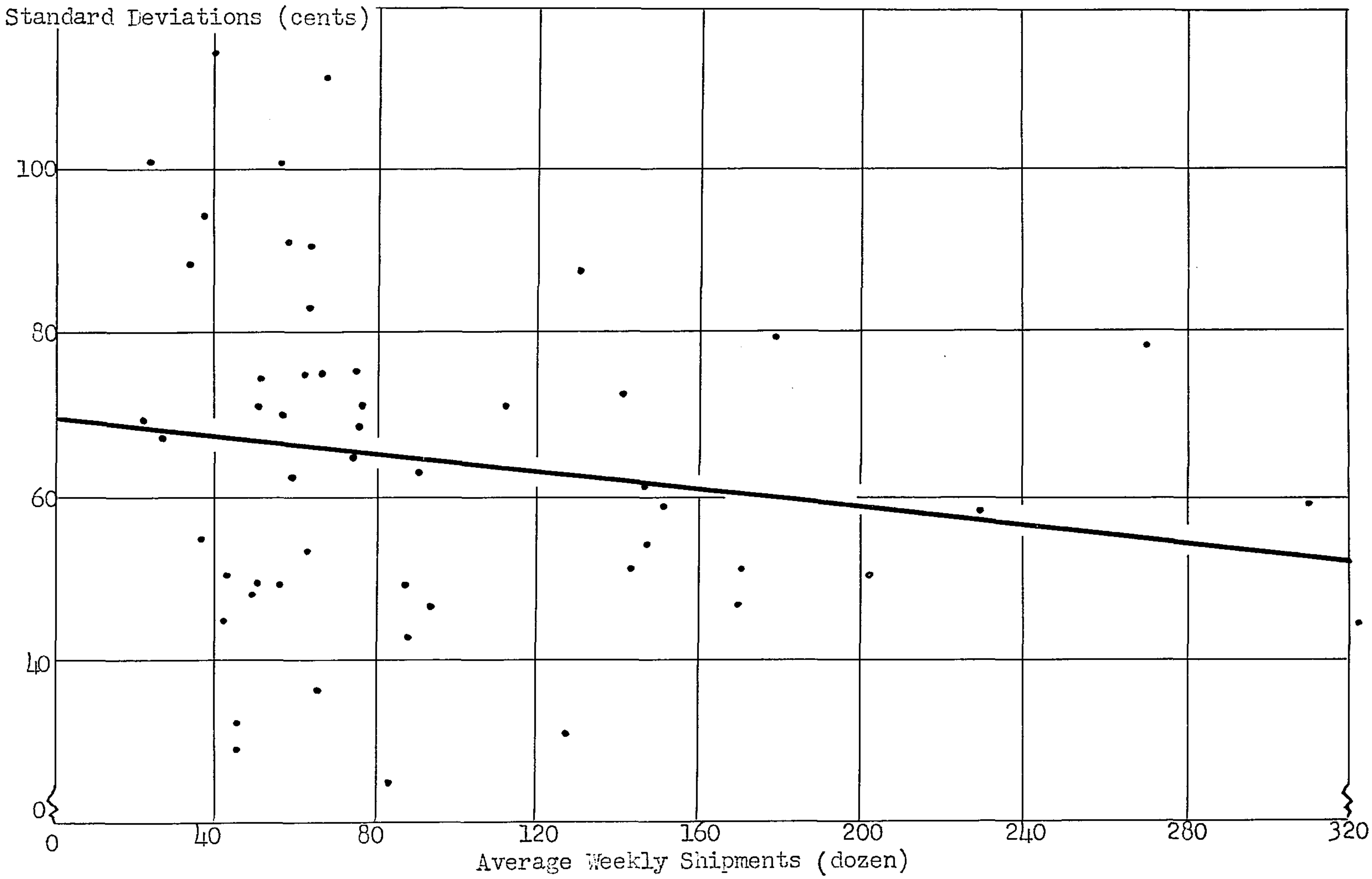
CHART VII Regression of the Standard Deviation on the Average Weekly Shipment, Using the Total Shipment Every Fifth Week



SUMMARY AND CONCLUSIONS

Seven egg sampling methods were tested in an attempt to determine the accuracy of samples as a basis for paying producers for their entire shipment of eggs over a period of one to five weeks, as follows:

Method A - Grade of One Case Sample to Determine Grade of Entire Shipment for that Week.
" B - Grade of One Case Sample to Determine Grade of Entire Shipment that Week and Following Two Weeks.
" C - Grade of One Case Sample to Determine Grade of Entire Shipment that Week and Following Three Weeks.
" D - Grade of One Case Sample to Determine Grade of Entire Shipment that Week and Following Four Weeks.
" E - Grade of Entire Shipment Every Third Week as a Sample to Determine Grade of Entire Shipment the Following Two Weeks.
" F - Grade of Entire Shipment Every Fourth Week as a Sample to Determine Grade of Entire Shipment the Following Three Weeks.
" G - Grade of Entire Shipment Every Fifth Week as a Sample to Determine Grade of Entire Shipment the Following Four Weeks.

The weekly shipments of eggs of 40 producers were used to test sampling methods "A", "B", "C", "D", over a period of one year. The average shipments of these producers varied from 45 to 322 dozen per week for the year (Table XXIII).

The weekly shipments of eggs of 52 producers were used to test sampling methods "E", "F", and "G" over a period of one year. The average shipments of these producers varied from 22 to 322 dozen eggs per week for the year (Table XXVII).

The values of the samples on a per case basis were compared with the average values per case of the entire shipments based on the actual grading of the eggs. The weekly differences in these values per case were tested for bias with the "t" test. (Method of paired comparisons).

The "t" test was applied to test the hypothesis that - the mean difference equals zero, or the sampling method was not biased. This would mean that if producers were paid for eggs on the basis of the grading of the sample, that over the period of one year the overpayments for individual shipments would equal the underpayments and the total payments for the year would be the same as if the payments had been made on the basis of the actual grading of the entire shipments.

The number of significant "t" values found in each of the sampling methods indicated the number of instances when this hypothesis had to be rejected (Table XXXII). With a population of 40 (producers) the normal expectancy would be to find two significant "t" values, and with a population of 52 the normal expectancy would be to find slightly over 2.5 significant "t" values.

The number of significant "t" values found in each sampling method exceeded the expected number, but the sampling methods in which the analysis showed 4 or less significant values for "t" were considered unbiased and acceptable as a method for determining the grade of eggs for paying producers on a quality basis.

Further study should be made on the sampling methods in which five or six significant values for "t" were found, while the sampling methods with more than six significant values for "t" should be discarded as biased and unreliable as a basis for paying producers.

TABLE XXXII

The Distribution of the "t" Values Found with the Various Sampling Methods* According to the Probability of Occurence

Probabilities	40 Producers							52 Producers		
	Sampling Methods									
	A	B	C	D	E	F	G	E	F	G
under 5%	4	3	6	9	4	6	5	4	11	7
5 to 10%	2	7	3	6	5	3	4	5	3	5
10 to 20%	8	7	5	5	4	4	1	6	5	3
20 to 30%	5	4	5	5	3	3	8	2	5	8
30 to 40%	2	3	5	4	3	3	1	7	4	4
40 to 50%	4	5	2	3	4	4	4	6	4	6
50% and over	15	11	14	8	17	17	17	22	20	19
Total	40	40	40	40	40	40	40	52	52	52

* Sampling methods described on page

This criteria for accepting or rejecting a sampling method was established in light of the variation found in the grading of identical samples of eggs by different candlers, as shown in the first part of the study.

There are other factors which may need to be taken into consideration in determining the number of weeks for which a sample might be used as a criteria of the grade of the eggs. These should include seasonal factors such as periods of extremely hot weather, which have a serious effect on egg quality, or the time that pullets come into production, which has an effect on egg size. These factors would have more influence as the number of weekly payments based on the sample was increased.

Based on these criteria, sampling methods "A", "B", and "E" (Table XXXII) proved to be the most acceptable sampling methods for determining producer payments under the given conditions of price relationships, size of shipments and length of time.

Price fluctuations and the variability of the relationship between the prices of the various grades may need to be considered in applying the results of this study to other areas. Likewise the application of the sampling methods to other areas may also be limited by the range in the size of the shipments and to areas where single weekly shipments are made by the producers.

For example, methods "A" and "B" were found to be applicable to producers with average weekly shipments of 45 to 322 dozen and method "E" was acceptable for producers whose average size shipments range from 22 to 322 dozen per week. The sampling methods were all tested on the basis of use during a full year, and limited to producers that market eggs once a week.

A one case sample from every shipment (Method "A") appeared to be as satisfactory for determining producer payments of large shipments (200-300 dozen) as for the small shipments (45-75 dozen). Thirty dozen samples from shipments up to 300 dozen is more than a 10% sample, which is considered large in terms of sampling theory.

When a one case sample is used as a basis of payment for a number of following weeks (Methods "B", "C", and "D"), the number of significant "t" values increased with the length of time the sample was used. Although basing the payments to producers on a one case sample for three shipments (the shipment from which the sample was taken and the following two shipments), was acceptable, use of a one case sample tended to become biased when used for periods of four or five weeks.

The use of the grade of the entire shipment every third week as a basis for determining producer payments the following two weeks (Method "E") also proved to be a satisfactory sampling method.

However, when the use of the grade of the entire shipment was used as a sample to cover a longer period, as the basis of payment for the next three or four weeks, there were too many occasions when the "t" value was significant, indicating too much bias and lack of reliability in this method of sampling. More investigation should be made of these methods. Methods ("F" and "G") may be satisfactory for large producers but not small ones. A large number of significant values (11 and 7) were found when the small producers were included in the analysis (Table XXXII).

The analysis showed that many of the significant values for "t" were found in the small size shipments which probably indicates that the quality of the eggs from small producers showed a greater week to week variation than the quality of eggs from the larger producers.

There was no consistent tendency for any of the sampling methods investigated to overpay or underpay the producers. About half of the mean differences were negative and the other half were positive - indicating about an equal number of underpayments and overpayments. Twenty-four of the significant "t" values were positive and twenty were negative.

The location of the significant "t" values in relation to the average weekly shipments show that in most instances only one of the sampling methods was not acceptable (significant at the 5% level). Only one producer showed three sampling methods which had significant "t" values, eight showed two, and twenty-five producers showed only one sampling method with a significant "t" value (Table XXXIII). There was little relationship between the significant values for "t" and the size of the weekly shipments, the color of the eggs, or the plant.

The standard deviation of the differences between the average value per case of the samples and the average value per case based on the grade of the entire shipments was used to measure the amount of the overpayments or underpayments on a single shipment (Table XXIV). Sampling method "A" (one case sample every week) showed the smallest overpayments and underpayments (35.48¢), and method "G" showed the

TABLE XXXIII

The Size of the Average Weekly Shipments of Eggs and the Location of the Significant (5% level) "t" Values Found with the Use of the Various Sampling Methods[1] Followed in Determining Payments for Eggs on a Quality Basis to 52 Producers

White Egg Shipments				Brown Egg Shipments			
Plant I		Plant II		PlantI		Plant II	
AWS	SM	AWS	SM	AWS	SM	AWS	SM
doz.		doz.		doz.		doz.	
24.5*	F	27.0*	F	21.9*	F	37.0*	-
36.8*	-	42.1*	-	34.4*	G	40.0*	F
50.1	G	48.8	-	41.2*	-	45.1	D
54.9	F-G	63.7	G	51.4	A	45.3	-
55.9	D	74.5	D-F	58.4	-	49.6	D
56.4	B-C-F	75.3	F	62.5	D-E	58.2	-
62.0	F-D	75.4	-	63.2	B-E	82.3	D-E
63.2	-	112.7	-	64.6*	-	200.9	F
76.4	-	125.4	C	67.1	C		
89.0	-	140.5	F	86.0	B		
129.7	C	146.0	C	86.5	A		
142.3	D-E	168.0	-	92.1	C-D		
151.8*	F	169.0	A	145.9	-		
178.8*	G			227.1	A		
270.6	-						
309.8	-						
322.1	F						

1 - Sampling Methods described on page

AWS - Average weekly shipment

SM - Sampling methods showing significant "t" values (5% level)

* Used only when testing methods E - F - G

largest (64.30 and 70.06¢) per case. The size of the standard deviations increased with the increase in the number of shipments for which the sample was used as the basis of payment.

The standard deviations of the differences between the values per case based on samples and the average value per case based on the grade of the entire shipment about the same as the standard deviations of the differences in grading between candlers grading identical samples of eggs. The standard deviation of the differences between the various candlers listed in Tables XVI and XVII ranged from 38.5¢ to 92¢ per case. The average was 68¢ per case. This would indicate that the variation in the average value per case based on the sampling methods and the average value per case found in the grade of the entire shipment in determining the amount paid the producer.

The size of the standard deviations was greater when the entire shipment was used as a sample than when a single case was used as a sample for determining producer payments during succeeding weeks. The average of the standard deviations was 52.7¢ per case when one case every third week was used as a basis of payment for the shipment from which the sample was taken and the following two shipments. (Method "B"). When the entire grade of one shipment every third week is used as a basis of payment for the following two weeks, the average standard deviation was 53.7¢ (Method "E").

When the latter method was used, all the eggs in every third shipment was graded, so that only two-thirds of the payments to producers during a year are paid on the basis of a sample. The standard deviations computed for methods "E", "F", and "G" apply only to these shipments that were paid for on the basis of a previous or sample shipment, since there would be no difference in the payment for the shipments used as samples.

The average standard deviation of sampling methods "E", "F", and "G" were larger when the records for the 52 producers was used instead of the records for only 40 producers. This indicates that the variation between the average value per case in these sampling methods and the average value per case based on the actual grade may be greater for the smaller producers (less than 45 dozen) than for the larger producers. The standard deviations showed a tendency to increase as the average weekly shipments became larger in the analysis of the records of the 40 producers with average weekly shipments of from 45 to 322 dozen per week. When the small shipments (less than 45 dozen) were included, the standard deviations showed a tendency to decrease as the average weekly shipments became larger. Regression lines based on the analysis of these sampling methods cannot be used as indicators of the variation resulting from these sampling methods, because the size of the standard deviations were found to be independent of the size of the sample. The coefficient of correlation was very small for all of the sampling methods tested.

The quality factor may be one possible reason why the standard deviations were as large for the small shipments as the large shipments. Although a 30 dozen sample from a 300 dozen shipment was a much smaller per cent of the total shipment than a 30 dozen sample from a 50 or 60 dozen shipment, the average quality of the 300 dozen

TABLE XXXIV

The Average Standard Deviations of the Differences between the Values per Case of Eggs Based on the Various Sampling Methods and Values Based on the Actual Grading of the Entire Shipment

Sampling Methods	Standard Deviations	
	40 Producers	52 Producers
	(cents per case)	
Method A - Grade of one case sample to determine grade of entire shipment for that week	35.48¢	-
Method B - Grade of one case sample to determine grade of entire shipment that week and following two weeks	52.77¢	-
Method C - Grade of one case sample to determine grade of entire shipment that week and following three weeks	54.49¢	-
Method D - Grade of one case sample to determine grade of entire shipment that week and following four weeks	58.26¢	-
Method E - Grade of entire shipment every third week as a sample to determine grade the following two weeks	53.70¢	61.52¢
Method F - Grade of entire shipment every fourth week as a sample to determine grade the following three weeks	56.05¢	61.69¢
Method G - Grade of entire shipment every fifth week as a sample to determine grade the following four weeks	64.30¢	70.06¢

shipments was probably more uniform.

Producers shipping an average of 300 dozen eggs each week have more at stake in the egg business and are more specialized than the small producer, therefore probably do a better job in the production and care of the eggs. In using a 30 dozen sample as a basis of payment, the one case sample was selected at random from 10 cases, if there were 300 dozen in the shipment. In a shipment of 45 dozen, there would be only one full case that could be selected as a sample and this case would probably include the oldest or lowest quality eggs in the shipment, since these eggs would be the first case packed and the partial case would contain the freshest eggs.

In summary, the sampling procedures of: (1) using the grade of a 30 dozen sample from each shipment, as a basis of payment for the entire shipment (Method "A"), (2) using the grade of a 30 dozen sample as a basis of payment for the entire shipment and also using the sample as the basis of payment for the following two shipments (Method "B"), and (3) using the grade of one entire shipment as the basis of payment for the following two shipments (Method "E") appear to be satisfactory and reliable methods of sampling to determine the payment to producers for eggs on a quality basis under the given conditions of price relationships, size of shipments, and the period of time involved in this analysis.

Further study needs to be made of the use of the entire grade of one shipment as a basis of payment for the four or five succeeding weeks, and more consideration should be given to the use of larger and smaller samples than the 30 dozen sample used in this study.

If a limited number of the better and more experienced candlers are used to grade the samples of eggs, the use of these sampling methods as a basis for determining producer payments should reduce the week to week variation in the grading and returns to producers due to the variation in grading between different candlers.

There would also be considerable savings in the plant operating costs because there would be no need of keeping the eggs from each producer separate and making stop and start counts between the grading of the eggs from different producers.

APPENDIX

1. Method of calculation of Chi Square

x = observed m = expected S = sum

In order to use machine calculations the basic formula for Chi Square ($X^2 = S(x-m)^2/m$ is transformed to $S(x^2/m)-n$ and applied in the following example. The data is from Test No. 1 - white eggs (Table I).

Candler		U.S. Grades A	B	C	Checks	Ined.	Total
S	x	0	666	33	11	7	717
	m	27.9	382.9	31.6	133	10	
	x^2/m	0	1158.4	34.5	9.1	4.9	
L	x	371	285	41	15	8	720
	m	280.4	384.5	31.7	13.3	10	
	x^2/m	490.9	211.2	53.0	16.9	6.4	
N	x	469	201	21	14	15	720
	m	280.4	384.5	31.7	13.3	10	
	x^2/m	784.5	105.1	13.9	14.7	22.5	
	Total	840	1152	95	40	30	2157

Expected Values

$840 \times 717 \div 2157 = 279.2$ (Grade A - Candler S)

$840 \times 720 \div 2157 = 280.4$ (Grade A - Candler L) etc.

$S(x^2/n) = 0 + 1148.4 + 34.5 \; \ldots\ldots\ldots\ldots\ldots \; 22.5 = 2926.0$

$X2 = S(x^2/n) - N = 2926 - 2157 = 789$

Degrees of Freedom = $(r-1)\ (c-1) = (3-1)\ (5-1) = 8$

2. Calculation Analysis of Variance (one-way "F" test

Example: Table X - brown eggs

n = no. candlers = 3   k = tests = 8   x = no. grade A eggs

Candlers

	E	X	G	
	106	56	87	
	51	25	90	
	127	21	46	
	165	42	37	
	56	22	66	
	104	23	57	
	129	94	103	
	65	27	25	
Sx	803	310	511	1624
Sx^2	92,009	16,544	37,993	146,546

a. Correction (C) = $(SSx)^2/nk = (1,624)^2/24$ = 109,890.6

b. Total (T) = SSx^2 - C = 146,546 - 109,890.6 = 36,655.4

c. Between means (B) = $S(Sx)^2$-C = 1,002,030/3 - 109,890.6 = 15,363.15

d. Within groups (W) = T - B = 36,665.4 - 15,363.15 = 21,292.25

Degrees of Freedom: Total = nk - 1 = 24 - 1 = 23
Between means = n - 1 = 3 - 1 = 2
Within groups n(k-1) = 3(8-1) = 21

Analysis of Variance

Source	Sum of squares	d.f.	Mean square	F ratio
between means	15,363.15	2	7,681.5750	7.576
within groups	21,292.25	21	1,013.9167	
Total	36,655.40	23		

3. Calculation of "Paired Comparisons" - "t" test

Example: Table X - brown eggs

Candlers X		G		
x1	-	x2	=	x
50	-	34		16
38	-	103		-65
56	-	87		-31
25	-	90		-65
21	-	46		-25
42	-	37		5
22	-	66		-44
23	-	57		-34
94	-	103		- 9
51	-	70		-19
66	-	43		23
27	-	25		2

Candler X = x1 Candler G = x2 $x = x1 - x2$ $Sx = -246$

$\bar{x} = -20.50$ $Sx^2 = 14{,}384$ $(Sx)^2/n = (246)^2/12 = 5{,}043.00$

$Sx^2-(Sx)^2/n = Sx^2 = (n-1)s^2 = 14{,}384 - 5{,}043 = 9{,}341$

$s^2 = 9{,}341/11 = 849.1818$ $s = \sqrt{849.1818} = 29.1407$

$S^2_{\bar{x}} = s^2/n = 849.1818\ /12 = 70.765$ $s_{\bar{x}} = 8.412202$

$t = \bar{x}/s_{\bar{x}} = 20.50/8.4122 = \underline{2.4368}$ d.f. = 12 - 1 = 11

$t_{05} = 2.201$

4. The Value per Case of Eggs Based on the Grade of a One Case Sample and the Value per Case Based on the Grade of the Entire Shipment Each Week for One Year

Plant no. 1 White eggs Graders: N-2 Z-1 V-3 F-1 S-2
Producer Harry Overmyer No. 167 L-2 E-4 D-3 H-1 K-1
Total ship. 3975 doz. Year Oct. 25, 1952 G-1 O-2 M-1 R-2 T-1
Av. per week 76.44 doz. to Oct. 26, 1953

Week	Total Dozen	Value Based on Grade One Case Sample	Value Based on Grade of Entire Shipment	Week	Total Dozen	Value Based on Grade One Case Sample	Value Based on Grade of Entire Shipment
		(per case)	(per case)			(per case)	(per case)
1	45	$--	$12.87	27	72	$15.53	$15.45
2	45	13.50	14.02	28	70	15.71	15.79
3	90	15.08	14.18	29	70	15.67	15.76
4	120	14.94	14.29	30	100	15.70	15.61
5	100	15.18	14.99	31	72	15.25	15.60
6	100	15.12	14.93	32	75	14.95	15.16
7	100	14.64	14.85	33	75	14.86	15.00
8	88	14.72	14.84	34	75	15.02	15.09
9	120	15.71	15.34	35	72	13.74	13.97
10	117	15.44	15.37	36	70	15.07	15.24
11	140	15.02	15.45	37	60	14.76	15.14
12	99	15.13	15.48	38	60	15.40	15.50
13	60	15.71	15.60	39	60	14.35	14.76
14	123	15.06	15.43	40	60	15.51	15.29
15	69	15.15	15.33	41	74	14.34	14.13
16	60	14.86	15.04	42	76	15.07	13.79
17	60	15.31	14.96	43	90	14.32	13.36
18	58	15.01	15.07	44	90	10.96	13.32
19	54	15.52	15.56	45	104	9.43	12.67
20	55	15.34	15.37	46	90	14.65	13.32
21	51	15.35	15.40	47	90	-	13.81
22	54	15.19	15.18	48	101	-	12.54
23	58	-	15.32	49	69	-	12.61
24	56	15.76	15.62	50	60	-	13.11
25	60	-	15.48	51	46	13.32	13.64
26	72	15.57	15.52	52	45	-	14.81

5. Calculation of Mean difference, Standard Deviation of Differences and "t" values. (Testing sampling method A - using the values per case of eggs from the producer shown in appendix 4)

Difference between the value per case of eggs based on the grade of a one case sample and values based on the grade of the entire shipment

(cents per doz.)	
52	- 5
-90	- 8
-65	8
-19	9
-19	- 9
21	35
12	21
-37	14
- 7	7
43	23
35	17
-11	38
37	10
18	41
18	-22
-35	-21
6	-128
4	-96
3	236
5	324
0	-133
-14	32

$SX = 350$

$\bar{x} = 7.95$ (Mean difference)

$n = 44$

$SX^2 = 236{,}603$

$(SX)^2/n = 2{,}784.09$

$s^2 = 233{,}818.91 \div 43$

$s = \sqrt{5437.649} \doteq 73.74$ (Standard Deviation)

$s_{\bar{x}}^2 \doteq s^2/n = 123.5829$

$s_{\bar{x}} = \sqrt{123.5829} = 11.11678$

$"t" = \bar{x}/s_{\bar{x}} = 7.95 \div 11.11678$

$"t" = .715543$

6. Calculation of Regression line of the Standard Deviations of the differences between the values per case based on the grade of a one case sample and the values per case based on the grade of the entire shipment. Source: Tables XXIII and XXIV

X = Average weekly shipment

$SX = 4,303.3$

$\bar{x} = 107.5825$

$SX^2 = 664,803410$

$(SX)^2/n = 462,959.772$

$(n-1)S_x^2 = 201,843.638$

$s_x^2 = 5,175.47789$

$s_x = 71.9407943$

Y = Standard Deviations

$SY = 1,305.258$

$\bar{y} = 32.63145$

$SY^2 = 50,793.9188$

$(SY)^2/n = 42,592.464$

$(n-1)s_y^2 = 8,201.293$

$s_y^2 = 210.293$

$s_y = 14.50$

$n = 40$

$SXY = 145,715.7739$

$(SX)(SY)/n = 140,422.9187$

$s_{xy} = 5,292.8552$

Regression line

$b = Sxy/(n-1)s_x^2 = 5,292.8552 \div 201,843.638 = .0262225$

$SY = n\ a + bSX = 1,305.258 = 40a + (.02622255)(4,303.3)$

$1,305.258 = 40a + (112.8435)$

$1,305.258 - 112.8435 = 40a$

$a = 29.81$

$Y = 2981 + .026223\ X$

7. Calculation of Coefficient of Correlation (r) between the Standard deviations of the differences and the size of the average weekly shipments. Source: Appendix 6.

$s_y^2 \cdot s_x^2 = 8{,}201.4578 \cdot 201{,}843.638 = 1{,}655{,}412{,}079$

$\sqrt{s_y^2 \cdot s_x^2} = 40{,}686.7550$

$r = s_{xy} / \sqrt{s_x^2 \cdot s_y^2} = 5292.8552 \div 40{,}686.755$

$r = .1300879$ (coefficient of correlation)

8. "t" test of "r" -- Test the hypothesis: "the standard deviations of the differences are independent of the size of the average weekly shipment." Source: Appendix 6 & 7

$"t" = r \sqrt{(n-2)/(1-r^2)} = .1300879 \quad = \quad \sqrt{(40-2)/(1-.01692286)}$

$= .1300879 \cdot \sqrt{38/.98307714}$

$"t" = \underline{.8085029}$

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AUTOBIOGRAPHY

I, Paul Chester Clayton, was born near Upper Sandusky, Ohio, October 16, 1924. I received my high school education at Bucyrus High School, Bucyrus, Ohio. My undergraduate training was obtained at The Ohio State University, from which I received the degree Bachelor of Science in agriculture in 1949. From The Ohio State University, I received the degree Master of Science in 1950. During this period I was employed as a Cooperative Agent (U.S. Department of Agriculture and the Ohio Agricultural Experiment Station). In 1951 I was appointed as a research assistant at the Ohio Agricultural Experiment Station and acted as an assistant to Professor R.E. Cray until I completed the residence requirements for the degree Doctor of Philosophy in 1952. In 1952 I received the appointment of Extension Economist at the University of Nebraska. I held this position until 1954 when I accepted the position of Extension Specialist in Poultry Science at The Ohio State University.